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The relationship between fruit and vegetable intake and declarative nutrition knowledge of residents in Blacon aged 17-45 years.

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Abstract

Purpose: Despite the reported health benefits of consuming fruit and vegetables on a daily basis, many residents of areas of deprivation, such as Blacon, still do not appear to be meeting the '5 a day' recommendations. This study assessed the correlation between declarative nutrition knowledge (the awareness of processes, events and constituents of food substances) and fruit and vegetable intake in a LLSOA (low-level super output area) in the North West of England. The aim was to understand the relevance of providing factual advice and recommendations to increase fruit and vegetable consumption.

Method: 42 participants (16 males and 26 females) took part in this cross sectional, correlational study. All participants completed a nutrition knowledge questionnaire (adapted from Parmenter and Wardle, 1999) and a dietary instrument for nutrition education (DINE) (Roe et al, 1994). During analysis, the participants were categorised in to age and gender groups. Average scores for fruit and vegetable consumption and declarative nutrition knowledge were compared. Nutrition knowledge was used as the independent variable against fruit and vegetable consumption in order to observe a correlation between the two.

Results: Spearmans Rank Correlation Coefficient showed that a statistically significant positive correlation was apparent between combined daily fruit and vegetable intake and total declarative nutrition knowledge ($r_s = 0.33$, $p = 0.033$). Although numerous correlations were observed, none appeared stronger than combined daily fruit and vegetable intake and expert advice ($r_s = 0.368$, $p = 0.016$). Females scored significantly better than males in expert advice ($U = 124$, $p = 0.020$) and daily fruit intake ($U = 129.5$, $p = 0.035$). The eldest age group (35-44 years) performed significantly better than the middle age group (25-34 years) for answers on health and disease ($F(2,39) = 5.588$, $p = 0.007$).

Conclusion: The significant findings from this study indicate that, while food intake is a complex issue involving a wide range of factors, declarative nutrition knowledge could be used to predict a small percentage of variance of fruit and vegetable intake in Blacon. This is significant for health authorities, governments and local communities, as efforts should continue to convey health messages and provide advice to the people who consume the least amount of fruit and vegetables in the least affluent areas.

Declaration of Academic Integrity

I hereby declare that work contained herewith is original and is entirely my own work (unless indicated otherwise). It has not been previously submitted in support of a Degree, qualification or other course.

Signed………………………………………………………

Date………………………………………………………….

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List of Abbreviations

BHF (British Heart Foundation)

CHD (coronary heart disease)

LLSOA (Low Level Super Output Area)

NCD (non-communicable diseases)

NHS (National Health Service)

UK (United Kingdom)

WHO (World Health Organization)

Chapter 1.0. Review of the literature

1.1. Introduction

Fruit and vegetables are regarded as one of the most important sources of nutrients and non-nutritive food constituents in human nutrition (Boeing et al, 2012). Current research suggests that fruit and vegetables play a significant role in preventing disease thus highlighting the importance of consuming them on a daily basis (Slavin & Lloyd, 2012). Due to the apparent importance of fruit and vegetables in the human diet, it is imperative to assess whether the population are meeting dietary recommendations, particularly those in areas of deprivation where non-communicable disease (NCD) prevalence is highest (Pearson, Taylor & Masud, 2004). This literature review will assess the evidence of the benefits of fruit and vegetables for human health, the current estimates for fruit and vegetable consumption in the United Kingdom (UK) compared to other countries, the effect of population demographic and the suggested predominant factors behind these figures with specific focus on nutrition knowledge.

1.2. Plant intake and links to disease

The benefits of eating fruit and vegetables as part of a well-balanced diet have been well documented (Roe, 1986; Serdula et al, 1996; Basu, Rhone & Lyons, 2010; Slavin & Lloyd, 2012). Reviews of current literature suggests that the micro- and macronutrients contained in fruit and vegetables including potassium, folate, vitamins, fibre, phenols and phenolic compounds have been shown to reduce antioxidant stress, improve lipoprotein profile, lower blood pressure, increase insulin sensitivity and improve hemostasis regulation thus reducing the risk of a number of chronic diseases (Van Duyn & Pivonka, 2000; Barrett, Beaulieu & Shewfelt, 2010).

1.2.1. Coronary heart disease (CHD)

Statistics from the British Heart Foundation (BHF) (2010) suggest that heart and circulatory diseases claim more lives than any other disease in the UK and CHD is regarded as one of the most common and serious form of cardiovascular disease (British Heart Foundation, 2010). Murray et al. (2013) reported that the UK had significantly higher rates of age-standardised years of life lost due to cardiovascular and circulatory disorders including ischaemic heart disease, aortic aneurisms and chronic obstructive pulmonary disease than the average for the original 15 members of the European Union, Australia, Canada, Norway and the USA. Furthermore, statistics from the BHF (2011) suggest that 74,000 deaths per year in the UK are caused by CHD and approximately 17% of annual male deaths and 11% of annual female deaths are attributable to CHD. These figures highlight the fact that CHD is the most common cause of death in under 75's in the UK, emphasising the seriousness of the disease.

There are some positive signs however, as the number of annual deaths attributable to CHD appears to have been reducing every year since 1985, although the number of CHD related deaths in younger people is reducing slower than the elderly (BHF, 2011). This may be in part due to more people suffering with the disease at an older age (65-74 years) and therefore more scope to influence a larger number of people and reduce actual death totals. These statistics may be slightly exaggerated due to the requirement of the foundation to achieve funding but nevertheless they highlight the importance of finding preventative interventions to reduce the risk and health burden for the UK population. The continued reduction in CHD related deaths over the past 25 years has been contributed to improved cardiac treatment but also, in part, to the increased public awareness and understanding of risk factors associated with the onset of the disease (Ford & Capewell, 2011).

Over the past 20 years, various studies have suggested that one of the most significant risk factors for contracting CHD is low fruit and vegetable consumption (Knekt et al, 1994; Key, Thorogood, Appleby & Burr, 1996; Ornish et al, 1998, Key et al, 1999; Dauchet, Amouyel, Hercberg, & Dallongeville, 2006).

Knekt et al. (1994) reported a significant protective effect of a diet high in fruit and vegetable intake against death from CHD during a longitudinal study of 5,133 men and women in Finland. The results of this study were particularly significant as a large number of lifestyle factors were controlled for including age, smoking, gender, obesity and energy intake thus suggesting these factors were not contributing to the results.

Key et al. (1996) also highlighted the importance of fruit and vegetable intake as they identified that eating a larger amount of fruit and vegetables daily could reduce the risk of heart disease related death by between 21% and 32%.

Following this, Ornish et al. (1998) concluded that a diet containing predominantly fruit and vegetables with minimal animal and dairy products may reverse the effects of CHD without the need for medication, however other lifestyle changes including stopping smoking and increasing exercise may have offered a positive contribution to this.

Furthermore, Key et al. (1999) identified in a study of 76,172 men and women that mortality rates from ischaemic heart disease was 24% lower in vegetarians than non-vegetarians (death rate ratio: 0.76; 95% CI: 0.62, 0.94; $P < 0.01$).

Finally, Dauchet et al. (2006) concluded, using a meta-analysis of nine cohort studies consisting of a total of 91,379 men and 129,701 women, that eating an extra portion of vegetables per day can reduce the risk of coronary heart disease (CHD) by 4% and that eating an extra portion of fruit per day could reduce the risk of CHD by 7%. The funnel plot describing the relationship between the relative risks of CHD and the standard error of the relative risks for all 9 studies showed pronounced asymmetry. The least significant relative risk studies were associated with the least significant standard errors and the most significant relative risk studies associated with the most significant standard error. The fact that this portrayed an inverse funnel suggested possible publication bias thus questioning the reliability of the results. Further limitations of this study include that the studies used different dietary assessment methods, they investigated different varieties of fruit and vegetables, location and socio-economic status analyses were not performed and seven of the nine studies were conducted in North America, which may have caused a lack of dietary variation.

Despite these results, questions remain whether both food groups contribute equally to the prevention of CHD and whether fruit and vegetable intake has a directly positive effect on CHD risk and mortality. This may be because different fruits and vegetables provide differing nutrients and calories (kcals) therefore more research is required to identify if different types of fruits and vegetables (leafy green vegetables, citrus fruits, etc.) confer a greater protection against CHD. None of the studies mentioned previously separated the different types of fruits and vegetables but recent studies have suggested that absolute quantity of fruit and vegetable consumption rather than variety may protect against CHD incidence (Griep, Geleijnse, Kromhout, Ocké and Verschuren, 2010; Griep, Geleijnse, Kromhout, Ocké and Verschuren, 2012).

Furthermore, although many positive relationships exist between fruit and vegetable consumption and CHD risk, the most significant mechanisms behind this relationship are unclear. Possible mechanisms include reducing antioxidant stress, improving lipoprotein profile, lowering blood pressure, increasing insulin sensitivity or improving homeostasis regulation predominantly driven by protective constituents such as potassium, folate and fibre (Dauchet, et al, 2006) but more research is required to fully understand this.

Although there are still uncertainties regarding the mechanisms and the extent of the relationship, the evidence provided by the studies mentioned previously, suggest that fruit and vegetables contribute significantly to reducing the risk and incidence of CHD related mortality.

1.2.2. Cancer

Cancer mortality is on the rise in the UK with over 175,000 people suffering cancer related deaths each year (Office of National Statistics, 2012). Approximately 270,000 new cases of malignant cancer were identified in England in 2010, which represented a 2% increase compared to the previous year (Office of National Statistics, 2012). The four most common areas of cancer presentation include lung, breast, prostate and colorectal (making up 53% of all cancer registrations) and it has been suggested that promoting healthy dietary habits including increasing fruit and vegetable intake may prevent a significant proportion of cancer cases (Jemal et al, 2011).

1.2.2.1. The mechanisms by which fruit and vegetables may protect against cancer

Fruit and vegetables are rich sources of nutrients (eg, fibre, vitamins, carotenoids, and phytochemicals) that have anticarcinogenic properties. The internal human processes effected by these nutrients include steroid hormone concentration modulation, steroid hormone metabolism modulation, immune system stimulation and DNA synthesis and methylation (Bárta et al, 2006). These mechanisms have encouraged many researchers over the past 30 years to assess the effectiveness of fruit and vegetable intake on reducing the risk of cancer in certain sites including the oesophagus, head, neck, stomach, lung, prostate and colorectum (Doll & Peto, 1981; Jemal et al, 2011).

In contrast to CHD, conflicting research is evident on the positive effects of fruit and vegetable intake and cancer risk. Gandini, Merzenich, Robertson and Boyle (2000) compared 17 studies across the world via a meta-analysis and identified an inverse relationship between vegetable intake and breast cancer risk (RR=0.75 (95% CI, 0.66-0.85)) thus leading to the conclusion that vegetable consumption in particular may reduce the risk of breast cancer. Although meta-analysis has been used frequently to compare randomised control trials, comparing disease risk factors using this method is much less common. Furthermore the difference in study qualities and the differing countries hosting the studies makes it very difficult to compare results and provide blanket conclusions therefore the significance of the results from Gandini et al. (2000) is dubious.

Similar conclusions were documented by Cohen, Kristal and Stanford (2000) who recognised that consuming 28 portions of vegetables per week may reduce the risk of prostate cancer compared to consuming 14 portions per week (odds ratio, 0.65 (95% [CI] = 0.45-0.94) $p = 0.01$) in individuals under the age of 65 years. No correlation was found between fruit consumption and prostate cancer risk and the use in this study of food frequency questionnaires to ask participants to estimate usual dietary patterns over the period of several years provides doubts about the accuracy of the data collected.

Additionally, Vainio and Weiderpass (2006) concluded that the fraction of selected cancers preventable by consuming fruit and vegetables was approximately 5-12% when comparing between 4 and 28 studies for each cancer site. Again, the variation in study designs, in particular the food frequency questionnaires used, and the variation in country of origin of the studies involved makes it very difficult to apply an overarching conclusion for the entire population.

More recent studies have questioned the positive effects of fruit and vegetable intake on cancer risk. George at al. (2009) identified that fruit and vegetable intake only significantly effected thyroid cancer in men and that smoking status was a much better predictor of cancer. For women, no significant effects of fruit and vegetables were observed for cancer risk.

Concurrently, the World Cancer Research Fund (2014) describe the positive effects of fruit and vegetables and cancer risk as 'probable' and while they do advise eating 5 portions of fruit and vegetables per day to stay healthy, much more emphasis is placed on high fibre foods such as wholegrain bread, wholegrain pasta and oats to reduce cancer risk, particularly bowel cancer. Lack of evidence means that the effectiveness of fruit and vegetable consumption for modifying common cancer risks such as colorectal, breast and prostate is questionable (Key, 2011). Based on the evidence mentioned previously, more research is required to assess the effectiveness of high fruit and vegetable rich diets on specific cancer sites and it is also important to monitor the interaction of a variety of food groups in the diet in the prevention of cancer.

1.2.3. Diabetes

Diabetes prevalence and future estimates since 2000 indicate that diabetes is fast emerging as an epidemic across the world (Wild, Roglic, Green, Sicree & King, 2004). In 2000 it was estimated that 2.2% of the population (171 million adults) had the disease and the projection for 2030 was that 4.4% of the population (366 million adults) would contract it at some point during their lifetime (Wild et al, 2004). The most recent studies now estimate that the world prevalence of diabetes will be 7.7% of the population (439 million adults) by 2030 emphasising the growing burden of the disease, particularly in developing countries (Shaw, Sicree & Zimmet, 2010).

It appears that the most attributable lifestyle risk factors for type II diabetes mellitus include obesity, diet, smoking, alcohol consumption and physical activity with 35% lower risk for each positive lifestyle factor (relative risk, 0.65; 95% confidence interval, 0.59–0.71) (Mozaffarian, 2009). While a diet high in fruit and vegetables may have an indirect effect on obesity reduction in conjunction with a low fat and sugar diet (Epstein et al, 2001), the nutrient content of fruits and vegetables may also play a direct role in reducing risk of contracting type II diabetes mellitus.

In general, the evidence for the direct effect of fruit and vegetable intake on diabetes mellitus is limited and inconclusive with some studies suggesting that fruit and vegetables may provide a preventative effect but they provide no solution once the disease has been contracted (Ford & Mokdad, 2001).

An example of this is Hamer and Chida (2007) who identified in a systematic review that consuming 3 or more portions of fruit and vegetables per day was not associated with a significant reduction in risk of diabetes mellitus. The language constrictions and limited number of studies included appeared to lead to more recent studies attempting to prove a positive relationship.

A more recent study by Harding et al. (2008), suggested that raised plasma vitamin C levels may lead to a substanitially decreased risk of diabetes mellitus (odds ratio in top quintile of 0.38, 95% confidence interval, 0.28-0.52) and to a lesser extent fruit and vegetable intake may lead to the same conclusion (odds ratio in top quintile of 0.78, 95% confidence interval, 0.60-1.00). This link appears clear due to the high vitamin C content found in many fruit and vegetables such as oranges, courgette and lemons but these would have to be separated within the fruit and vegetable category before this relationship could be confirmed.

Furthermore, a systematic review conducted by Carter, Gray, Troughton, Khunti, and Davies (2010) suggested that a greater increase of leafy green vegetable consumption contributed to a 14% (hazard ratio 0.86, 95% confidence interval 0.77 to 0.970) reduction in risk of diabetes mellitus (p=0.01). Interestingly, this study concluded that, other than green leafy vegetables, no other fruit, vegetables or combination of the two showed any benefits in reducing the onset of diabetes mellitus. Again, the limited number of studies included may have effected the results in addition to the lack of knowledge as to whether other vaiables including lifestyle factors such as physical activity and smoking were controlled for. Despite these limiting factors, the conclusions from this study suggest that vitamin C may not be the predominant dietary factor in reducing type II diabetes mellitus risk.

More research is required to determine the effects of specific fruit and vegetable intake on diabetes risk and the interaction of other dietary components with fruit and vegetables.

Additionally, the exact mechanisms of how fruit and vegetables may effect the risk of diabetes are unknown although current literature suggests it may involve the antioxidant and phytochemical properties combatting free radicals and reducing oxidative stress (Miller, Rigelhof, Marquart, Prakash, & Kanter, 2000). Overall it appears that if fruit and vegetables reduce the risk of diabetes mellitus, it is highly likely to be indirect by effecting other risk factors and the effect of fruits naturally high in sugar may have an inverse effect.

1.2.4. Alzheimers

Alzheimers is generally accepted as the most common cause of dementia, affecting approximately 496,000 people in the UK (Alzheimers Society, 2011). Alzheimers causes the death of brain cells that can result in loss of memory, severe mood changes, problems with communicating and difficulties reasoning (Alzheimers Society, 2011). During the onset of alzheimers, it is believed that chronic accumulation of reactive oxygen species in the brain may exhaust anti-oxidant capacity (Honda, Casadesus, Petersen, Perry & Smith, 2004). Additionally, researchers suggest that hydrogen peroxide may mediate oxidative damage caused by the β-amyloid peptide during the onset of Alzheimer's disease (Dai, Borenstein, Wu, Jackson & Larson, 2006), which is where fruit and vegetables may have a positive impact.

The polyphenols found in many fruit and vegetables may counteract the negative effects caused by hydrogen peroxide, thus facilitating anti-oxidant capacity during reactive oxygen species accumulation and therefore may provide a mechanism for the prevention of alzheimers through fruit and vegetable intake (Dai et al, 2006).

This is supported by Kang, Ascherio and Grodstein (2005) who discovered that cognitive decline was accelerated in women who didn't eat as many fruit and vegetables, particularly green leafy vegetables although fruit intake showed no association with the prevention of cognitive decline. The evidence provided is relatively recent compared with other illnesses and diseases so more research is required but early signs certainly suggest that increased fruit and vegetable intake may contribute to a slower cognitive decline, however this may depend on the culinary process as peeling and boiling can lead to a loss of certain polyphenols (Manach, Scalbert, Morand, Remesy & Jimenez, 2004).

This is counteracted by Nooyens et al. (2011) who concluded from a prospective study of 7,769 men and women using multivariate linear regression that general fruit and fruit juice consumption showed no significant improvement in cognitive function. In the same study, vegetable consumption actually contributed to a low information processing speed (p=0.02) and cognitive flexibility (p=0.03), thus providing no significant positive contribution to the onset of alzheimers. Despite this, consumption of cabbage and root vegetables was associated with reduced decline in cognitive domains memory (p=0.02). Confounders such as age, sex, alcohol consumption, smoking status and level of education were adjusted for to ensure that fruit and vegetable consumption was the predominant contributor to the correlation against cognitive decline.

Unfortunately, however, the 20% drop-out from the initial baseline participation meant that the numbers were made up using a selection of newly recruited participants who actually scored lower on all cognitive domains compared to the group that participated twice. This may have negatively affected the validity of the results but cross-sectional associations between fruit and vegetable consumption and cognitive function were comparable between the groups that did and didn’t take part.

The NCD’s mentioned in this section account for 59% of annual deaths worldwide and remain as high mortality causes across the United Kingdom (Boyle & Langman, 2000; Mackay, Mensah, Mendis & Greenlund, 2004; Khaw et al, 2008). Apart from the physical health detriments, the financial burden that NCD's place on various countries is significant. In 2007 it was estimated that diabetes alone contributed to 10% (£9 billion) of the total NHS spends in the UK, which is the equivalent of £286 per second (NHS, 2007).

Diet has been identified as one of the three preventable risk factors that play a key role in the development of NCD's (the other two being tobacco use and alcohol) (Beaglehole, 2011). While the greatest dietary risk is identified as the comsumption of foods high in saturated fat, it is clear from the evidence presented that fruit and vegetable consumption is a significant contributing factor. Therefore this has led to organisations such as the World Health Organization (WHO) implementing guidance and promotional programmes referring to adequate fruit and vegetable consumption quantities to counteract these diseases.

1.3. Fruit and vegetable consumption

1.3.1. Global consumption compared to dietary recommendations

The WHO (2003) advised that the global target for fruit and vegetable consumption should be five portions per person per day. Current evidence focussing on the estimates of fruit and vegetable intake in the UK and numerous developed countries suggests that the population appear not to be meeting the recommended intakes (Serdula et al, 1995; Perez, 2002; Serdula et al, 2004; Hall, Moore, Harper & Lynch, 2009).

Hall et al. (2009) identified that more than 50% of the population of 49 out of 52 surveyed countries consumed less than the recommended 5 portions of fruit and vegetables per day. The surveyed countries represented the six World Health Organisation regions and high-, middle- and low-incomes (78% from low- and middle-income countries), however the UK was not one of the selected countries.

Prior to this, Perez (2002) identified that although Canadian women consumed a higher amount of fruit and vegetables per day than men, neither group were consuming the recommended 5 portions. The same study concluded that for both sexes, as age increased, so did fruit and vegetable consumption and men with a diagnosed heart condition would eat fruit and vegetables approximately 0.4 times more frequently per day than those unaware of the health implications, which proved to be statistically significant ($p<0.05$).

Furthermore, Serdula et al. (2004) highlighted (although not statistically significant) a slight decrease in fruit and vegetable consumption frequency of American adults from 3.44 times per day to 3.37 times per day over a 6 year period from 1994-2000 with the average intake between 3 and 4 servings per day. Serdula et al. (2004) also concluded that the 65 years + age group consumed more fruit and vegetables than any other age group whereas the 25-34 were least likely to consume 5 portions of fruit and vegetables per day although methodological limitations such as varying food frequency questionnaire administration throughout the 6 year period may have accounted for the small changes.

A study conducted previously by Serdula et al. (1995) indicated a smaller intake of fruit and vegetables by adults (3.3 for men and 3.7 for women) in the United States but this was administered as a telephone interview rather than questionnaire.

In England, according to the National Diet and Nutrition Survey, household purchases of fruit and vegetables fell by 8.5% between 2006 and 2009 (Bates, Lennox & Swan, 2010). Furthermore, it was discovered that fresh fruit in particular fell dramatically by 3.1% from 2008 to 2009. The reasons for this decline remain unknown although price rises have been offered as a deterrant of fruit and vegetable purchasing. It may be logical to assume that a reduction in purchasing would be associated with a reduction in consumption.

This survey also concluded that fruit and vegetable intake increased with age until approximately 64 years; a trend that was replicated in the most recent report from 2011-2012 (170g/day total fruit and vegetable consumption for 11-15 year olds compared to 331g/day for those aged 50-64 years) (Bates, Lennox & Swan, 2012). This proposed that young adults consistently consumed fewer fruit and vegetables than their older counterparts.

While most developed countries follow a similar trend in terms of total fruit and vegetables consumed with regards to age and sex demographic, it appears that consumption trends also follow similar patterns between countries depending on area of residence.

1.3.2. Fruit and vegetable consumption in areas of deprivation

General diet quality has been shown to follow a socioeconomic gradient where individuals living in more affluent areas appear to consume a higher quality diet including whole grains, lean meats, low fat dairy products, fish and fresh fruits and vegetables (Darmon & Derwnowski, 2008).

It’s therefore no surprise that various studies have concluded that mortality and morbidity rates follow a similar pattern where the lowest socioeconomic areas also suffer from higher rates of cancer, diabetes, obesity, cardiovascular disease and osteoporosis (Evans, Newton, Ruta, MacDonald & Morris, 2000; Molarius, Seidell, Sans, Tuomilehto & Kuulasmaa, 2000; Tang, Chen & Krewski, 2003; Pearson et al, 2004).

Much of the previous research on the fruit and vegetable consumption of populations with a low socioeconomic status has predominantly focussed on income. For example, Giskes, Turrell, Patterson and Newman (2002) identified in a cross-sectional study in Ausralia that lower income adults consumed less fruit and vegetables than adults who received a higher income. Additionally, the higher income group were 3 times more likely to have eaten fruit on the previous day. Similarly in a large cross-sectional study of 353,005 adults in USA, Grimm, Foltz, Blanck and Scanlon (2012) found that the percentage of people with the lowest income consuming at least 3 portions of fruit and vegetables per day (21.7%; <130% PIR) was significantly lower than the percentage of people with the highest incomes (30.7%; >400% PIR).

In 2000, Wardle, Parmenter and Waller compared the fruit and vegetable intake of 1040 participants in the UK, categorised in to two of the socioeconomic factors: education and occupation. They found that participants with a degree level education consumed significantly more fruit (0.3 portions/day +/- 0.25; p=0.01) and vegetables (0.4 portions/day +/- 0.2; p<0.001) than their counterparts with no qualifications. Similar results were apparent for occupation with participants with the highest occupational level consuming significantly more fruit (0.7 portions/day +/- 0.4; p=0.03) and vegetables (0.7 portions/day +/- 0.4; p=0.002) than their unemployed counterparts. Although these combined two socioeconomic factors, the residency of the participants wasn't documented so it was impossible to tell whether the participants resided in an area of deprivation.

Shohaimi, et al. (2004) assessed whether fruit and vegetable consumption could be predicted depending on location in Norfolk and used area of deprivation as a variable. They found that fruit and vegetable consumption was 31g/day lower for men (p<0.001) and 17g/day lower for women (p=0.03) for participants residing in areas of deprivation compared to those living in the most affluent areas. As this study used the Townsend deprivation index (Townsend, Phillimore & Beattie, 1988), areas of deprivation were categorised around material deprivation and although occupational social class wasn't included, the material deprivation factors were income and finance based.

While these studies offer an invaluable insight in to the effect of a low income on fruit and vegetable consumption, many other factors contribute to the status of an area of deprivation. These include education, income, employment, health, crime, access to services and living environment (Office of National Statistics, 2010).

Despite the apparent positive effects of fruit and vegetables on human health mentioned previously in this literature review, very few studies have assessed the fruit and vegetable consumption of areas described as being health deprived.

1.3.3. Why such a low intake?

The wide-spread nature of low fruit and vegetable intake has led researchers to look for reasons that may prevent people from consuming an adequate amount of fruit and vegetables.

Havas et al. (1998) identified that self efficacy and perceived barriers may be strong predictors of fruit and vegetable intake for women in Baltimore and Maryland in the USA. Women who were reported to be most self-confident tended to consume the largest amount of fruit and vegetables (increase of 0.76 servings per 1 S.D. increase in self-efficacy). Concurrently, women who perceived few barriers to purchasing and sourcing fruit and vegetables were most likely to consume them on a regular basis (decrease of 0.50 servings per 1 S.D. increase in perceived barriers). To explain this further it was important to identify individual barriers and assess them on individual merit rather than clustering them in to one group of 'perceived barriers'.

Previous studies have assessed numerous limiting factors and perceived barriers to fruit and vegetable consumption for areas of deprivation including accessibility, quality and spoilage rates, time (preparation and working), cost and fast food alternatives with differing results (Kratt, Reynolds & Shevchuk, 2000; Sieger-Riz & Popkin, 2001; Pomerlaeu, Lock, Knai & McKee, 2005; Yeh et al, 2008). Nutrition knowledge has been studied in the UK for the past 15 years and has shown that lack of knowledge may be a significant limiting factor for fruit and vegetable intake in a variety of locations and socio-demographic groups (Parmenter, Waller & Wardle, 2000; Ha & Caine-Bish, 2009; Palmer, Salisbury-Glennon, Shannon & Struempler, 2009).

1.4. How do we define nutrition knowledge?

Humans use knowledge to explain and predict aspects and events of the world (Epstein,1994) but before assessing the importance of nutrition knowledge in relation to food intake, it's important to distinguish the difference between belief and knowledge. Beliefs are based on perceived links and relationships between two concepts e.g. causation and effect. Beliefs can also be formed by linking previous knowledge-based concepts, however many beliefs are made up on a spur of the moment basis and can't be categorised as knowledge until strong evidence has been identified (Worsley, 2002). Contrastingly, knowledge is based on a combination of evidence, experience and a meta-schema of beliefs (Worsley, 2002) and so is much more reliant on scientific evidence and facts, which allows more influence from organisations and researchers.

Nutrition knowledge, as one may expect, can be described as knowledge of nutrients and nutrition although it is difficult to recognise the domains and extent of knowledge required by consumers to make informed decisions with regards to food intake. Knowledge can be seperated in to two domains: procedural and declarative. While declarative (or descriptive) knowledge is the awareness of processes, events and constituents of substances, procedural knowledge is the knowledge of how to perform or operate (Anderson, 1995). In a nutritional sense, an example of declarative knowledge would be that vegetables have low fat content or that high intakes of fruit and vegetables can help prevent the onset of certain diseases. An example of procedural knowledge would be if someone was to explain the role of certain fruits and vegetables to prevent the onset of certain diseases or how to eat a healthy diet.

Many nutrition knowledge questionnaires contain a mixture of both procedural and declarative knowledge domains, however it is unclear which domain is the most significant when influencing food intake. Although procedural nutrition knowledge has been assessed previously (Dickson-Spillmann, Siegrist & Keller, 2011), there is little evidence to distinguish between the nutrition knowledge domains.

Current fruit and vegetable specific, population-based health interventions led by health authorities and the UK government deliver messages aimed to improve declarative nutrition knowledge, with perhaps the most significant being the '5 a day' campaign (Department for Environment, Food & Rural Affairs, 2004). It is important to understand whether improving declarative nutrition knowledge is positively correlated with fruit and vegetable consumption to assess the impact and relevance of current interventions.

1.4.1. The link between nutrition knowledge and food consumption

A number of studies have successfully assessed a relationship between nutrition knowledge and food consumption and these have led to conflicting results (Shepherd & Stockley, 1987; Wardle, Parmenter & Waller, 2000; Dickson-Spillmann & Siegrist, 2011).

Shepherd and Stockley (1987) concluded that personal attitudes were better predictors of fat consumption than nutrition knowledge which didn't appear to relate to food consumption or the attitudes towards food suggesting that nutrition knowledge was not an important factor in food choice or consumption.

Contrastingly, in an attempt to broaden the scope of study of knowledge and diet beyond fat and fibre, Wardle et al. (2000) administered a nutrition knowledge survey to 1040 participants in England in order to understand if there was a link between nutrition knowledge and fruit and vegetable intake. They found that nutrition knowledge was significantly correlated with fruit ($r = 0.23$, $p<0.001$), vegetable ($r = 0.36$, $p<0.001$) and fat ($r = -0.21$, $p<0.001$) intake and respondants in the highest quintile for nutrition knowledge were 25 times more likely to meet recommended intakes of fruit, vegetables and fat compared to those in the lowest quintile. The results from this study portray that nutrition knowledge could explain anywhere between 4% and 22% of variation in food intake thus suggesting that nutrition knowledge is a contributing (if not predominant) factor in explaining variations in food choice.

Limitations exist for both studies. Firstly, Shepherd and Stockley (1987) were focusing purely on fat consumption rather than any other macronutrient or food groups and the nutrition knowledge tool they used had not been validated previously. Wardle et al. (2000) assessed a correlation between fruit and vegetable intake and nutrition knowledge but the age ranges in this study were not consistant and there were a varying number of participants in each age group, particularly the 18-34 year group. Finally the questionnaire respondants appeared to be predominantly women, of higher occupational class and have higher education qualifications, which may have led to a higher healthy eating estimation than would have been identified in a more proportionately diverse sample.

Dickson-Spillmann and Siegrist (2011) identified that increased procedural nutritional knowledge was associated with increased vegetable, fruit and water consumption in Swiss nationals.This study included participants with nutrition related qualifications, which may have influenced the results as they may have had more recognition as to the amounts of fruit and vegetables that they were recommeded to consume.

Perhaps the most significant conclusion from this study was that nutrition-specific procedural knowledge was generally good but poor for those who considered a healthy diet to be the equivalent of just consuming vitamins and that many misconceptions regarding a healthy diet were apparent such as eating less of every food is healthy, fat should be completely excluded from the diet and that fruits could be completely replaced with fruit juice or tablets. This indicated that more information was required to teach the practical implications of the food pyramid, the concept of a balanced diet and the importance of eating more fruit and vegetables.

In general, it appears that, while nutrition knowledge may play a role in changing food behaviours, it is unclear which population demographic or food group it is most influential for.

1.4.2. Nutrition knowledge of residents in deprived areas

Many studies assessing diet quality in socioeconomic areas categorize and analyse individuals based on overall education rather than nutrition knowledge (Darmon & Derwnowski, 2008; Hiza, Casavale, Guenther & Davis, 2013). Previous studies have included demographic variations in nutrition knowledge in the results when assessing nutrition knowledge and fruit and vegetable consumption (Parmenter et al, 2000). Nevertheless the researcher is unaware of any other studies in the UK that have been conducted solely in an area of health deprivation and disability (Office of National Statistics, 2010).

In England, areas of deprivation are categorised in to lower level super output areas (LLSOA) and are identified within 326 districts. The indeces of deprivation used to rank LLSOA’s are constructed from information of seven domains including education, income, employment, health, crime, access to services and living environment. All LLSOA’s are compared and ranked so the most deprived has the highest rank i.e. 1 and the least deprived LLSOA has the lowest rank. According to the Office of National Statistics (2010), the North West contained the highest number of LLSOA’s in England, which may partly explain why, according to the National Diet and Nutrition Survey, fruit and vegetable purchasing is low in the North West of England and vegetable purchasing in particular is the lowest in the country (less than 1kg per person per week for vegetables) (Bates et al, 2010).

Blacon has been identified as an LLSOA within the Cheshire West and Chester district. South Blacon and North Blacon are amongst the 1% (ranked 241/32,482) and 6% (ranked 1,800/32,482) most deprived LLSOA’s with regards to health and disability in the country.

Previous studies have shown that a link occurs between diet quality and living environment (Cummins & Macintyre, 2006; Darmon & Derwnowski, 2008). Additionally, a limited number of studies have suggested a link between fruit and vegetable consumption and socioeconomic status (including living in a deprived area) (Shohaimi et al, 2004; Kamphuis et al, 2006) but the researcher is unaware of any studies that have been conducted within an area of health deprivation to assess the fruit and vegetable consumption of the residents. Furthermore, no previous studies have identified the correlation between nutrition knowledge and fruit and vegetable consumption in a LLSOA classed as health deprived.

Additionally, the researcher is unaware of any previous studies that include the age ranges of 17-24 and 25-34 despite the low fruit and vegetable consumption and nutrition knowledge associated with this age range (Subar et al, 1995; Parmenter et al, 2000; Bates et al, 2010). Whilst nutrition knowledge-based interventions have been targetted towards children from 6-16 years (Parmer, Salisbury-Glennon, Shannon & Struempler, 2009), conflicting evidence and an uncertainty towards the significance has meant that this is not the case for adults. Moreover, the present study will focus specifically on declarative nutrition knowledge in an attempt to assess how effective this knowledge domain is when influencing dietary behaviour.

1.5. Objectives

The research objectives for this study include:

- To assess whether a correlation exists between declarative nutrition knowledge and fruit, vegetable or combined fruit and vegetable consumption for residents of a LLSOA in the UK.
- To assess whether males and females differ significantly in declarative nutrition knowledge or fruit and vegetable consumption in a LLSOA.
- To assess whether different age groups vary significantly in declarative nutrition knowledge or fruit and vegetable consumption in a LLSOA.

The results from the present study should help public health professionals understand the level of declarative nutrition knowledge and dietary behaviour of residents in Blacon with the aim of designing new interventions to tackle any issues raised. By assessing correlations between nutrition knowledge and food behaviour, local health professionals can also use these results to conduct further research to decide whether education based interventions are an effective method to improve dietary behaviour in Blacon and similar ares of deprivation. By encouraging the residents to consume more fruit and vegetables this may have a positive impact on the prevalence of NCD's in areas classed as health deprived.

Null hypothesis (H_0): There is no relationship between nutrition knowledge and fruit and vegetable intake of residents in Blacon.

Alternative hypothesis (H_1): There is a relationship between nutrition knowledge and fruit and vegetable intake of residents in Blacon.

2.0 Methods

2.1. Population and subjects

The participants for this cross-sectional, correlational study were aged between 17 and 45 years. The age ranges for the study were based on the lower age ranges declared by Wardle et al. (2000). The present study included an additional age range of 17-24 years to take in account those that finished full-time education at the age of 16. Therefore the three age ranges for this study were 17-24, 25-34 and 35-44. The target sample number was calculated as 102 by the validated GPower 3.1.2 (Faul, Erdfelder, Lang & Buchner, 2007), however this was not achieved as only 42 participants took part in the study (16 males and 26 females). 9 participants were aged 17-24 years, 16 were aged 25-34 years and 17 participants were aged 35-44 years. Further demographic information (home residence and employment status) were used for inclusion purposes.

2.2. Recruitment

A non-proportional quota sampling strategy was used to recruit the participants in an attempt to ensure all groups contained similar number of participants. The researcher is aware that non-proportional quota samping does not represent a proportional amount of the population, however it does allow the smaller population groups to be adequately represented as described by Morrow et al. (2007).

Ethical approval was obtained through the University of Chester before beginning the recruitment process (appendix A). The researcher attended community events and locations of high footfall within Blacon, Chester in 2011 to administer the questionnaires. Before preceeding with the questionnaire, the researcher explained that only participants who met the inclusion criteria would be eligible for the study. The inclusion and exclusion criteria for participants of this study are shown in table 1.

Table 1. Inclusion criteria for participants in this study

Inclusion Criteria	**Exclusion Criteria**
Residents of Blacon (CH1 5 postcode)	Aged below 17 years
Adults aged over 16 years	Public health professionals
Adults aged under 45 years	Adults aged over 45 years
Males and females	Non-English speaker
English speakers	Studying a nutrition-related course
	Currently in a nutrition-related job

The inclusion criteria questionnaire to ensure only eligible participants were recruited is shown in appendix B.

2.3. Materials and procedures

Participants who met all the inclusion criteria were asked to complete a nutrition knowledge questionnaire (adapted from Parmenter and Wardle, 1999) (appendix C) and a fruit and vegetable intake questionnaire (adapted from the validated dietary instrument for nutrition education (DINE) (Roe, Strong, Whiteside, Neil & Mant, 1994) (appendix D). The questionnaire used in this study focussed solely on declarative knowledge i.e. awareness of food varieties, nutrients and processes such as lemons are good source of vitamin C rather than procedural knowledge such as how to combine foods to produce a meal as this study aimed to identify whether people were more likely to choose foods based on how nutritious they were rather than whether they could cook with them and how tasty they were. The questions within this nutrition knowledge questionnaire in this study were based on facts and relationships that have been identified through evidence, experience and a meta-schema of beliefs. The nutrition knowledge questionnaire was adapted to only include questions related to fruit and vegetables and these were divided in to 3 sections including expert advice and expert recommendations (expert advice), food groups and relevance of fruit and vegetables for health and preventing diseases (health and disease). Similarly, only the fruit and vegetable related questions were used as part of the DINE questionnaire in order to minimise the completion time by participants. Fruit and vegetable portion size guidance (NHS, 2011a) was offered by the researcher to help the participants identify the relative amounts they consumed (appendix E).

All participants were informed of the study and the researchers involved before completing the questionnaires through the participant information sheet (appendix F). All participants were also asked to print their names on an informed consent form to confirm they understood and agreed to take part in the study (appendix G). The researcher also explained to the participants that they were free to leave any questions unanswered if they felt uncomfortable. A refusal to answer any questions in the food frequency questionnaire was marked as incorrect, whereas participants who refused to answer questions from the DINE were ommitted from the results of any analyses involving these questions.

2.4. Data management and data analysis

The nutrition knowledge questionnaire provided quantitative data and was analysed in the following way:

- The questions were split in to three sections including expert advice, food groups and health and disease.
- Participants were allocated one point for each correct answer to the questions (some questions allow more than one answer, in which case the participants were allocated more than one point). If a participants refused to answer a question for any reason, this was marked as incorrect i.e. 0 points, however, when administering the questionnaire, the researcher was unaware of any questions that the participants refused to answer.
- Points were added for each section and accumulated points were recorded for each participant.
- Points totals were recorded for each age group.
- Points were compared between age groups.

Answers for questions in the nutrition knowledge questionnaire were compared to a variety of sources that provided the most recent recommendations and advice for the UK population when the questionnaires were completed. These included the National Health Service (NHS, 2011a; NHS, 2011b; NHS, 2011c; NHS, 2011d; NHS, 2011e; NHS, 2011f;

NHS, 2011g), the Scientific Advisory Commission on Nutrition (SACN, 2003), the British Nutrition Foundation (BNF, 2011), the Food Standards Agency (FSA, 2002), World Health Organization (WHO, 2002), British Dietetic Association (BDA, 2011), Cancer Research UK (2009) and the British Heart Foundation (BHF, 2008). The recommendations used for each of the questions are outlined in appendices H, I and J.

The fruit and vegetable intake questionnaire was analysed in the following way:

- Participants were allocated one point for each portion of fruit and vegetables they consumed per week. If a participants refused to answer a question for any reason, this was marked as incorrect i.e. 0 points, however, when administering the questionnaire, the researcher was unaware of any questions that the participants refused to answer.
- Points totals were recorded for each age group.
- Points were compared between age groups.
- All questionnaires were anonymised.

The data was analysed using SPSS 20.0 (IBM Corp, 2011). Each set of data was tested for normality using frequency distribution histograms and Shapiro-Wilk tests ($n<100$). The data was analysed using three methods.

Firstly, the means of both nutrition knowledge results and fruit and vegetable intake of all three age groups were compared using a one-way independent group Anova and post hoc analysis. In addition to calculating whether the difference in the means were significant, the f value also provided the exact ratio of the variance among the means to the variance within the samples i.e. the higher the f value, the more substantial the variance between the group means compared to the variance of the samples thus suggesting a more significant difference between means (Larson, 2008). Non-normally distributed data was analysed using the Kruskal Wallis Anova and post hoc analysis. The variance of the ranks among the groups (adjusting for the number of ties) was denoted by the H value thus suggesting that the larger the H value, the more substantial the difference in the results between at least two of the groups (Kruskal, 1952).

Secondly, data for daily fruit and vegetable intake and declarative nutrition knowledge was entered in to scatter graph. For a linear relationship, as illustrated by the scatter graphs, had the data followed a normal distribution, it would have been analysed using the Pearsons Product Moment Formula. As all fruit and vegetable intake data proved non-normal, the linear correlations of daily fruit and vegetable intake and declarative nutrition knowledge were analysed using Spearman’s Rank Correlation Coefficient. The r_s value indicated the strength of the correlation in either direction with a positive value to a maximum of 1.0 providing a positive correlation and a negative value to a minimum of -1.0 providing a negative correlation (or correlation in the reverse direction) (Rodgers & Nicewander, 1988). For obvious curvilinear relationships, as illustrated by the scatter graphs, Curvilinear Regression was used to analyse the correlation.

Finally, the participants were split in to male and female groups and the means of these two groups for fruit and vegetable consumption and nutrition knowledge were compared using a two-tailed independent t-test. The t value denoted the difference between the means of the two groups (Wallenstein, Zucker & Fleiss, 1980). Non-normally distributed data was analysed using the Wilcoxon Mann Whitney 'U' test. The ‘U’ value signified the difference between the means of the two groups. The further the value was from half of the product of the number of values in the first group multiplied by the number of values in the second group, the larger the difference between the groups. The smaller the U value was (to a minimum of 0), the more significant the difference (Fagerland & Sandvik, 2009).

All the results were tested to a 0.05 significance i.e. the probability of the relationships found being due to a chance event is less than 5 out of 100.

3.0. Results

3.1. Nutrition knowledge

The results from the nutrition knowledge questionnaire were compared between the three age groups (17-24 years, 25-34 years and 34-44 years) and gender. In addition to the overall score, the scores from each section of the nutrition knowledge questionnaire (expert advice, food groups and health and disease) were compared between age groups and gender separately. Table 2 outlines the mean and standard deviations of correct answers for the declarative nutrition knowledge questionnaire for all 3 age groups and males and females.

Table 2. Mean and standard deviations of correct answers for the declarative nutrition knowledge questionnaire for age and gender

Variable	Mean Expert Advice (no. of correct answers)	Mean Food Groups (no. of correct answers)	Mean Health and Disease (no. of correct answers)	Mean Total Nutrition Knowledge Score (no. of correct answers)
Age 17-24 years	6.22 +/- 0.36	5.89 +/- 0.68	4.56 +/- 0.63	16.67 +/-1.49
Age 25-34 years	6.31 +/- 0.18	5.44 +/- 0.77	4.19 +/- 0.71	15.88 +/- 1.25
Age 35-44 years	6.65 +/- 0.36	5.82 +/- 0.54	7.06 +/- 0.66	19.53 +/- 1.26
Males	5.88 +/- 0.35	5.44 +/- 0.76	4.88 +/- 0.69	16.19 +/- 1.33
Females	6.77 +/- 0.16	5.85 +/- 0.43	5.77 +/- 0.58	18.35 +/- 0.97

Table 3. P values following comparison of means between all elements of nutrition knowledge and age and gender

Dependent variable	Independent variable	P Value
Expert Advice	Age	0.193
Food Groups	Age	0.966
Health and Disease	Age	**0.007**
Nutrition Knowledge	Age	0.104
Expert Advice	Gender	**0.020**
Food Groups	Gender	0.814
Health and Disease	Gender	0.338
Nutrition Knowledge	Gender	0.189

(Values in bold denote statistically significant results $p<0.05$)

3.1.1. Expert advice

From the data, it can be concuded that females (6.8 +/- 0.2 correct answers) performed significantly better than males (5.9 +/- 0.4 correct answers) on the expert advice and expert recommednations element of the nutrition knowledge questionnaire ($U = 124$, $p = 0.02$) as portrayed by figure 1 and table 3. No significant difference was oberved between age groups (17-24, 25-34 and 35-44) for correct answers on expert advice and expert recommednations ($H(2) = 3.286$, $p = 0.193$).

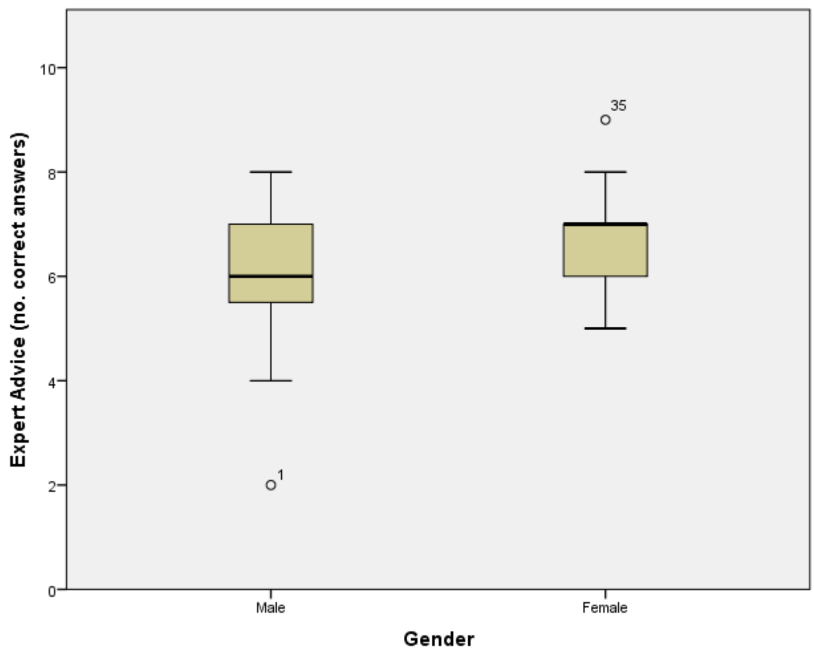


Figure 1. Box plot portraying the difference in correct answers for expert advice and expert recommendations between males and females

3.1.2. Food groups

Food group knowledge didn't differ significantly between males and females (U = 199, p = 0.814) or age groups (H (2) = 0.069, p = 0.966).

3.1.3. Health and disease

Tables 2 and 3 show that there was no significant difference apparant between males (4.9 +/- 0.7 correct answers) and females (5.8 +/- 0.6 correct answers) for questions related to the relevance of fruit and vegetables for health and preventing disease (t (40) = 0.971, p = 0.338). Contrastingly, significant differences were apparent between age groups for health and disease results (F(2,39) = 5.588, p = 0.007). A Turkey post-hoc test revealed that the results differed significantly between the 35-44 year age group (7.1 +/- 0.7 correct answers) and the 25-34 year age group (4.2 +/- 0.7 correct answers, p = 0.009). The was no significant difference in health and disease results between the 17-24 year (4.6 +/- 0.7

correct answers) and 35-44 year age groups (p = 0.065) or the 17-24 year and 25-34 year age groups (p = 0.939). Figure 2 portrays the difference in correct answers for health and disease between age groups.

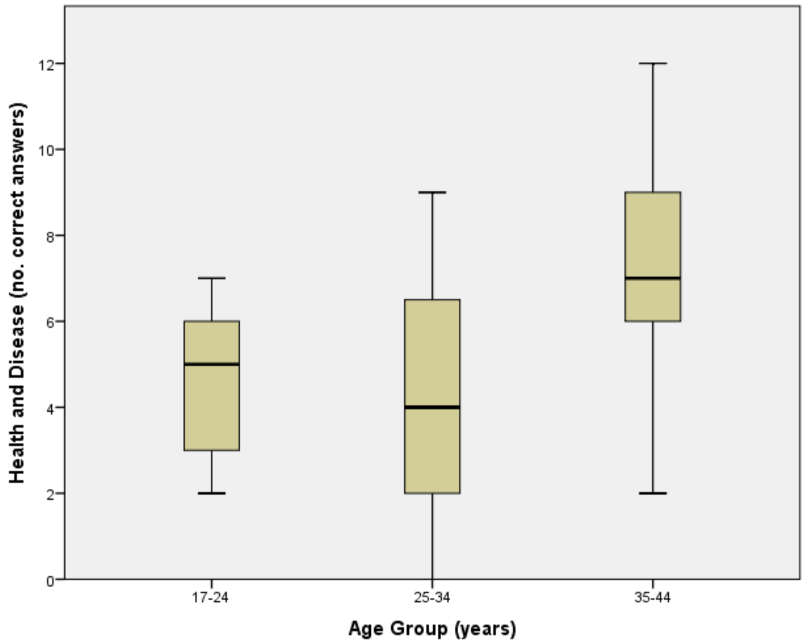


Figure 2. Box plot showing the difference in correct answers for health and disease between age groups

3.1.4. Total declarative nutrition knowledge

The data portrays no overall declarative nutrition knowledge statistical significance between males (16.2 +/- 1.3 correct answers) and females (18.4 +/-1.0 correct answers) (t (40) = +/-1.336, p = 0.189). Similarly, there was no sigfnificant difference in overall declarative nutrition knowledge between the age groups 17-24 years (16.7 +/- 1.5 correct answers), 25-34 years (15.9 +/- 1.2 correct answers) or 35-44 years (19.5 +/- 1.3 correct answers) (p = 0.104).

3.2. Fruit and vegetable intake

Daily fruit and vegetable consumption was compared between age groups and gender.

Table 4 portrays the mean and standard deviation for daily fruit and vegetable intake in all 3 age groups and for males and females.

Table 4. Mean and standard deviations of daily fruit, vegetable and combined intake for age and gender.

Variable	Mean Fruit Intake (portions per day)	Mean Vegetable Intake (portions per day)	Mean Total Intake (portions per day)
Age 17-24 years	1.44 +/- 0.34	2.00 +/- 0.53	3.44 +/-0.80
Age 25-34 years	1.31 +/- 0.34	1.75 +/- 0.27	3.06 +/- 0.54
Age 35-44 years	1.94 +/- 0.41	2.06 +/- 0.35	4.00 +/- 0.63
Males	1.00 +/- 0.24	1.81 +/- 0.34	2.81 +/- 0.56
Females	1.96 +/- 0.31	2.00 +/- 0.25	3.96 +/-0.47

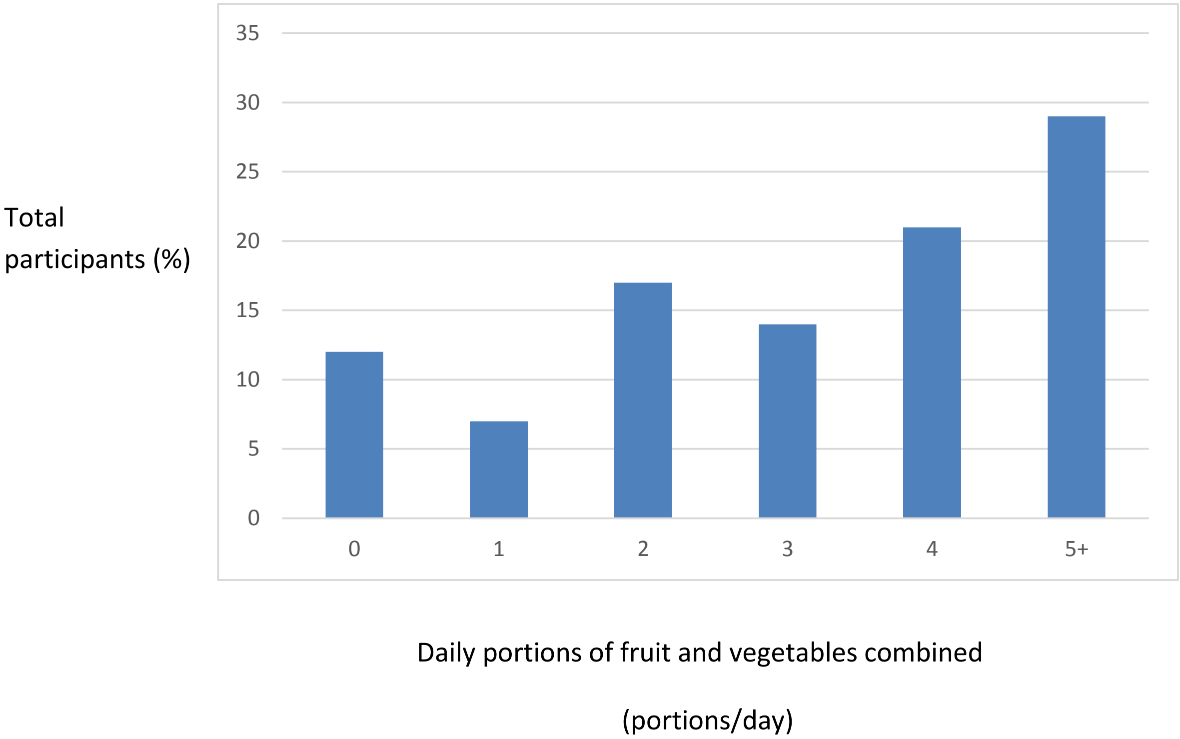


Figure 3. Percentages of participants consuming combined fruit and vegetable portions daily

Figure 3 describes that only 29% of the participants reported to eat a total of 5 portions of fruit and vegetables or more per day but 50% consumed at least 4 portions of fruit and vegetables daily. Table 5 also illustrates how 12% of participants reported to consume 0 portions of fruit and vegetables.

Table 5. P values following comparison of means between fruit, vegetable and combined consumption and age and gender

Dependent variable	Independent Variable	P Value
Veg Intake	Age	0.791
Fruit Intake	Age	0.435
Combined Intake	Age	0.533
Veg Intake	Gender	0.604
Fruit Intake	Gender	**0.035**
Combined Intake	Gender	0.129

(Values in bold denote statistically significant results $p<0.05$)

No significant difference was identified between age groups for daily vegetable (p = 0.791), fruit (p = 0.435) or combined fruit and vegetable intake (p = 0.533). Similarly, no significant differences were acknowledged between daily vegetable (U = 188.5, p = 0.814) or combined fruit and vegetable intake (t (40) = +/- 1.551, p = 0.129) between males and females, however table 6 portrays a significant difference between males and females for daily fruit intake (U = 129.5, p = 0.035). Values from table 4 indicate that the females involved in this study consumed significantly more fruit than males (2.0 +/- 0.3 portions for females, 1.0 +/- 0.2 portions for males).

3.3. Correlation

Declarative nutrition knoweldge scores and daily fruit and vegetable consumption were analysed to assess any correlation between the two.

The data portrayed a weak-to-medium-strength, positive correlation between combined daily fruit and vegetable consumption and overall declarative nutrition knowledge (r_s =

0.33, $p = 0.033$) as portrayed by figure 4. Furthermore it can be estimated that 10.89% of the variance in fruit and vegetable consumption can be predicted by declarative nutrition knowledge ($r^2 = 10.89$).

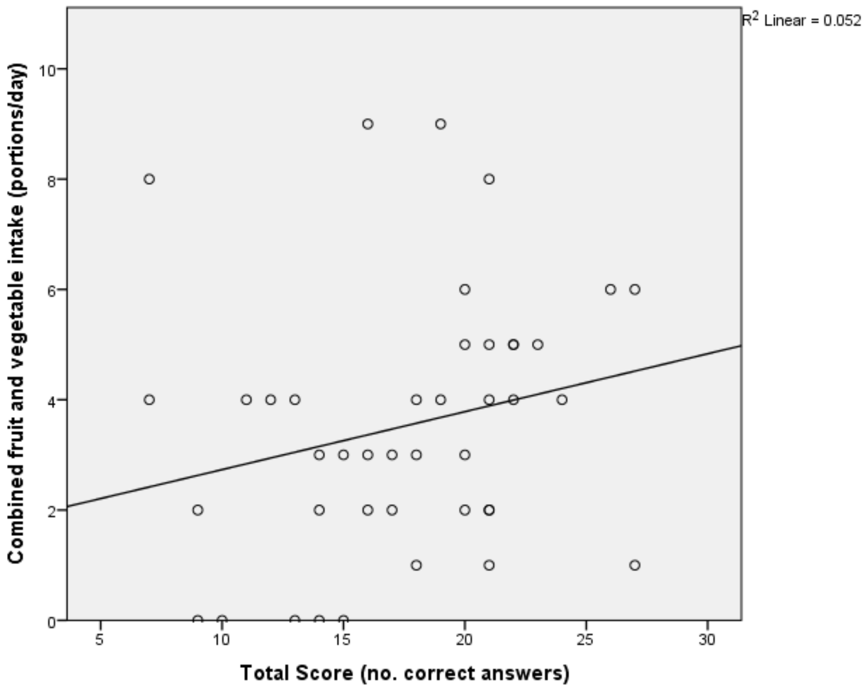


Figure 4. Scatter graph portraying the correlation between correct answers for overall declarative nutrition knowledge and combined daily fruit and vegetable intake and the corresponding line of best fit

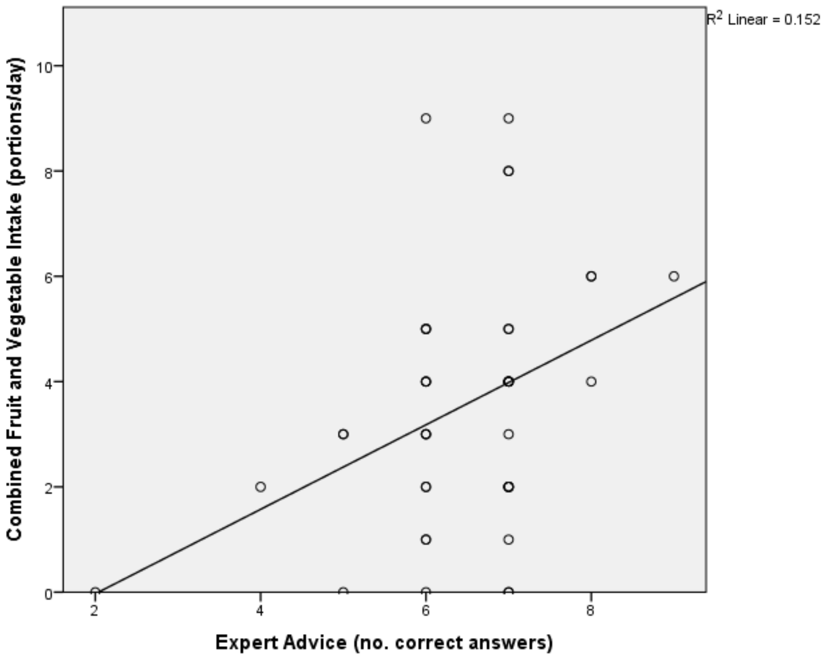


Figure 5. Scatter graph portraying the correlation between correct answers for expert advice and recommendations and combined daily fruit and vegetable intake and the corresponding line of best fit

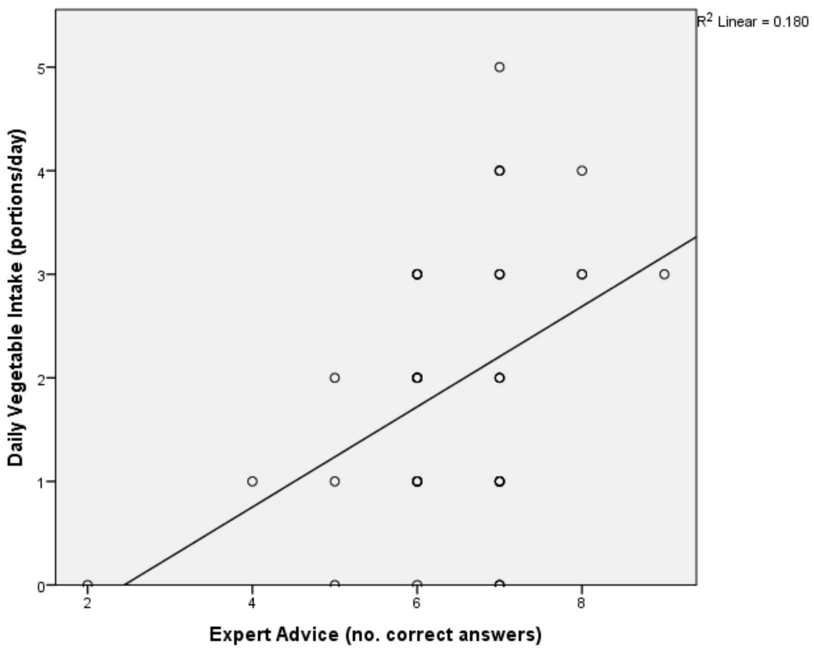


Figure 6. Scatter graph portraying the correlation between correct answers for expert advice and recommendations and daily vegetable intake and the corresponding line of best fit

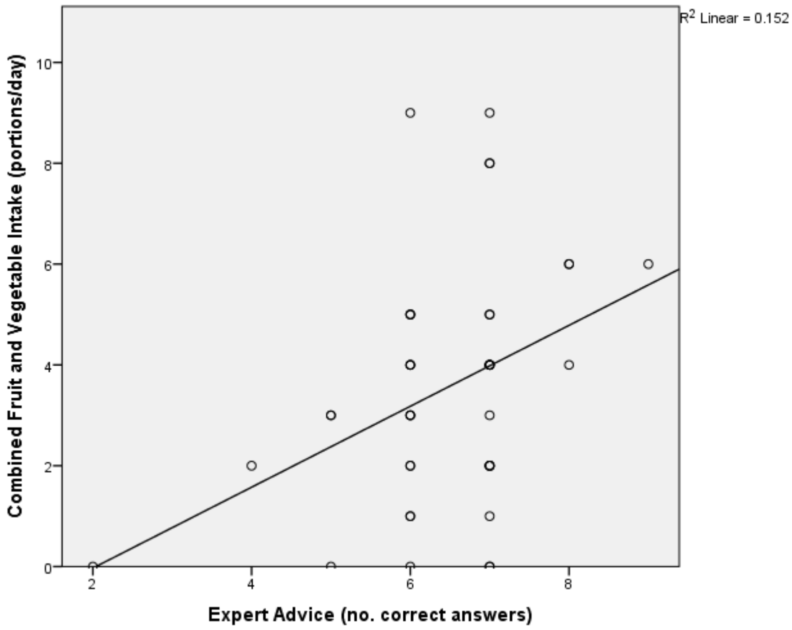


Figure 7. Scatter graph portraying the correlation between correct answers for expert advice and recommendations and combined daily fruit and vegetable intake and the corresponding line of best fit

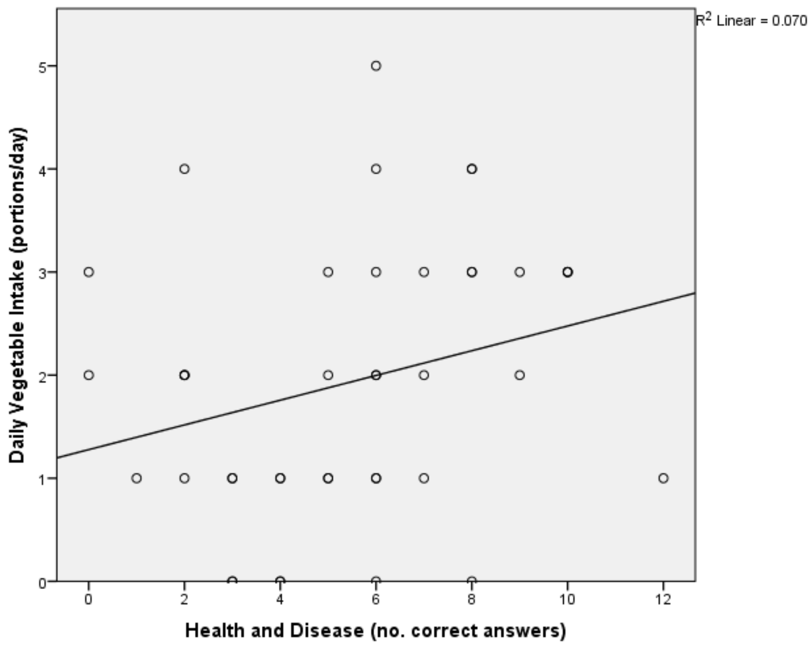


Figure 8. Scatter graph portraying the correlation between correct answers for health and disease and daily vegetable intake and the corresponding line of best fit

Within these variables, there appeared to be significantly positive correlations between daily vegetable intake and overall declarative nutrition knowledge (r_s = 0.384, p = 0.012) shown by figure 5, daily vegetable intake and expert advice and recommendations (r_s = 0.383, p = 0.012) portrayed by figure 6, combined daily fruit and vegetable intake and expert advice and recommendations (r_s = 0.368, p = 0.016) shown by figure 7 and daily vegetable intake and health and disease (r_s = 0.318, p = 0.040) portrayed by figure 8.

No significant correlations were observed for daily fruit intake (analysed seperately from daily vegetable intake) and any declarative nutrition knowledge elements.

4.0. Discussion

4.1. Fruit and vegetable intake

The present study concurs with many previous studies suggesting that fruit and vegetable intake is low in areas of deprivation (2.8 +/- 0.6 portions per day for males and 4.0 +/- 0.5 for females) when compared to the recommended 5 portions per day (WHO, 2003; Darmon & Derwnowski, 2008; Bates et al, 2010).

Conversely, the 29% of the population meeting the recommendations in this study is significantly higher than the 9% identified by Nelson, Bates, Chuch and Boshier (2007) when assessing the fruit and vegetable consumption of low income individuals as part of the Low Income Diet and Nutrition Survey. Although this may suggest that more residents within these areas are now conforming with current recommendations compared to 7 years ago, the methodological differences between the two studies mean that it is difficult to compare results directly.

Firstly Nelson et al. (2007) only included participants with the highest material deprivation (the lowest 15% in the UK) including income, benefit status, household composition, car ownership and employment status. In contrast, the present study focussed on a LLSOA that was selected due to a wide range of socioeconomic factors but mainly health. The location in the present study was ranked lower for health and disability than income or any other material deprivation factors, which may have accounted for the differing results.

Secondly Nelson et al. (2007) had access to many more participants (3,728) and was therefore a better representation of the most materialistically deprived households on a low income in the UK. The present study solely represents the residents of Blacon.

It is apparent from the evidence provided that low fruit and vegetable consumption may increase the risk of many NCD’s mentioned previously in this report such as CHD, cancer, diabetes and alzheimers but the results from the present study and Nelson et al. (2007) suggest health and disease may not necessarily be as significant an influence of fruit and vegetable intake as income. This is portrayed by only 9% of the participants from Nelson et al. (2007) consuming the recommended amount compared to 29% of the present study.

Despite the fact that these studies differ with regards to the percentage of the population from deprived areas that consume 5 portions of fruit and vegetables per day, they both infer that this is lower than the national average as described by the National Diet and Nutrition Survey from 2010-2011 (Bates et al, 2012), which identified that 31% of UK adults met the ‘5 a day’ recommendations (WHO, 2003). Although these figures are slightly higher than the 30% published by the survey in 2010 (Bates, Lennox & Swan, 2011), they are lower than the baseline figures published in 2009 of 35% (Bates et al, 2010), which suggests that fruit and vegetable consumption has not altered very much over the past 5 years and has actually decreased since the first survey in 2009.

While the present study has analysed a possible internal influence (declarative nutrition knowledge), the ‘deprivation amplification’ hypothesis may provide a more detailed answer to explain the gap between areas of deprivation and affluent areas regarding fruit and vegetable consumption (Macintyre, 2007). It suggests that residents of the most deprived areas of the country are exposed to the lowest quality neighbourhood food environments by environmental factors (such as transport) amplifying individual disadvantages (such as nutrition knowledge) (Macintyre, 2007). Simplified, this means that poorer neighbourhoods lack health promoting resources and are exposed to more health damaging resources. This means that low quality neighbourhood food environments may contain fewer residents who meet the '5 a day' recommendations due to a range of barriers that amplify their own individual issues. These barriers may include lack of public transport, high prices of fruit and vegetables, poor quality of fruit and vegetables, less access to health promotion service or better access to ready made food for home and out-of-home consumption e.g. takeaways (Cummins & Macintyre, 2006).

Since 2007, however, this theory has been challenged. Macintyre, Macdonald and Ellaway (2008) examined the location of 42 resources in Glasgow ranging from pawn brokers and private nurseries to Universities and golf courses. No clear pattern by deprivation was observed for any of the 3 food retail outlets (supermarket, café, takeaway) based on distribution and distance leading to the conclusion that access to resources does not always disadvantage poorer neighbourhoods in the UK.

Furthermore, in a study of 205 neighbourhoods in 4 environmental settings including island, rural, small town and urban in Scotland, Smith et al. (2010) identified that the most deprived areas actually had the best access to grocery stores selling fresh produce compared to least deprived (shortest travel time) in urban neighbourhoods (6.5 minutes compared to 15.2 minutes; p<0.0001). This was the opposite for large stores with fresh produce in rural neighbourhoods (182.1 mins compared to 53.1 mins; p=0.035). This led to the conclusion that 'deprivation amplification' theory could not be applied universally as associations between neighbourhood deprivation and grocery store accessibility varied by environmental setting.

Smith et al. (2010) estimated travel time by road distance and didn't take in to account the additional time incorporated by public transport for those who didn't have a car. In the assumption that a higher proportion of people in the most deprived areas travel via public transport (Lucas, Tyler, Christodoulou, 2008), actual travel time may have been longer, particularly in rural neighbourhoods and therefore would have portrayed differing results.

Moreover, participants from all areas had, on average, a store that was not selling fresh produce equidistant or a shorter distance away than a store selling fresh produce. This indicates that if travel time is the most influential factor for food consumption, most of the participants would have chosen the store that was closest i.e. the store that didn't sell fresh produce. While this does not necessarily effect the validity of 'deprivation amplification' as this was true of all areas, it may contribute to the reason why much of the UK population are not meeting the '5 a day' target.

The 2 studies described above assessed access to health and food resources via distance, distribution and travel time. Due to the limitations of both studies, perhaps a better way to assess 'deprivation amplification' and food access for residents of areas of deprivation would be through other factors such as overall shopping time, cost, quality and perceived accessibility. More studies should focus on this when considering how accessible health resources (including fruit and vegetables) are for residents of areas of deprivation so that 'deprivation amplification' can be better understood.

The health benefits of consuming fruit and vegetables as part of a healthy diet has already been discussed in detail in the literature review and the results from this study confirm the lack of fruit and vegetables in the diets of a very small sample of residents of an LLSOA in the UK thus increasing the risk of contracting serious illnesses and diseases such as CHD, diabetes, alzheimers and cancer (Dauchet et al, 2006; Rhone & Lyons, 2010; Jemal et al, 2011; Slavin & Lloyd, 2012). Although conflicting evidence exists for the relationship between fruit and vegetable intake and disease prevention, it must be recognised that neither human nor animal studies portray a harmful effect of increased fruit and vegetable consumption on health (George et al, 2009).

Furthermore, while fruit and vegetable consumption may not be the most influential risk factor for contracting any of these conditions, it may reduce the risk depending on other lifestyle factors based on evidence outlined in the literature review (Nooyens et al, 2011). As areas of deprivation generally provide a higher incidence of NCD's (Evans et al, 2000; Molarius et al, 2000; Tang et al, 2003; Pearson et al, 2004), it is important to design and evaluate interventions to increase the amount of fruit and vegetables consumed by residents of areas of deprivation.

In an attempt to tackle this, Jennings et al. (2012) evaluated a Mobile Food Store (MFS) run by Health Trainers that delivered affordable, quality fruit and vegetables and promoted positive behaviour change. This MFS travelled on a weekly basis to areas predominantly around Great Yarmouth and Lowerstoft where people were estimated to be consuming less than 1 portion of fruit and vegetables per day (NHS Great Yarmouth and Waveney, 2010). A paired samples t-test used to analyse before and after questionnaires of 255 customers, showed that fruit and vegetable consumption increased by an average of 1.2 portions per person per day (95%CI 0.83–1.48; p<0.001) since they had started using the MFS. 56% of the respondants attributed the increase in fruit and vegetable consumption to the MFS and 85% of respondants who ate less than portion of fruit and vegetables per day pre-intervention had increased this to over 1 porton post-intervention.

While this appears to be relatively successful in terms of increasing the amount of fruit and vegetables in an area of deprivation, there was only a 25% increase in the number of respondants consuming 5 or more portions of fruit and vegetables per day. Additionally, the fruit and vegetables from the MFS were being sold at cost price and the Health Trainer salaries were being funded externally suggesting that this wouldn't perhaps be a viable business idea for anyone that was not receiving external funding. Despite this, a higher proportion of the respondants viewed the convenience of the MFS (85%) to be beneficial compared to price (79%) so a slight increase in price may have been as equally accepted by the residents.

More longitudinal studies are required to assess similar interventions with the aim of increasing the fruit and vegetable consumption of residents of areas of deprivation using evidence gained from research on interal and external influencing factors. Once successful interventions have been identified, they could possibly be replicated in multiple areas around the UK.

4.2. Differences between genders

The suggestion from this study that females have a higher fruit intake than males is consistent with previous research (Baker & Wardle, 2003; Murphy et al, 2012). In a study of American adults, 60% of the participants who met the recommended five portions of fruit and vegetables per day were female, providing a stastistical significance (Murphy et al, 2012). Additionally, Baker and Wardle (2003) found in a study of 1024 older adults in the UK that women consumed significantly more portions of fruit and vegetables than men (2.57 vs 3.54; p<0.01).

The present study doesn't explore the most influential factors behind these differences. In contrast, Baker and Wardle (2003) suggested that preferences, dieting status and attitudes provided no significant attenuating effects in combined fruit and vegetable intake between men and women. On the other hand, they observed that nutrition knowledge may explain approximately 59% of the difference in fruit and vegetable intake between the sexes. The present study indicated that there was no significant difference in overall declarative nutrition knowledge or combined fruit and vegetable intake between males and females thus it doesn't support the claim by Baker and Wardle (2003).

Despite this, it appears that there may be a non-significant trend that females consumed more combined fruits and vegetables than males (table 4). Other than Baker and Wardle (2003), very few studies have attempted to understand the reasonings behind the apparent increased fruit and consumption in females compared to males.

Apart from nutrition knowledge, a factor that may have an influence on fruit and vegetable consumption between genders is age. The participants in the research conducted by Baker and Wardle (2003) were aged between 55 and 64 years whereas the participants in the present study were aged from 17-44 years, which may account for the slight variation in the conclusions beteen the two.

Previous research has focussed on younger age groups to assess the difference in fruit and vegetable intake between males and females with contrasting results. Reynolds et al. (1999) identified a significantly higher intake of fruit and vegetables in females than males in participants aged from 8-16 years. In contrast to this, Pearson, Atkin, Biddle, Gorley & Edwardson (2009) identified that adolescent boys consumed more fruit and vegetables per day than adolescent girls, however this was not assessed as statistically significant. More research is required to assess fruit and vegetable intake across a wider age range between males and females and the possible reasons for the difference in fruit and vegetable consumption between genders.

Table 2 portrays a possible non-significant trend that females performed better than males in all elements of the nutrition knowledge questionnaire, the significance of which may have been effected by the small sample size. The suggestion that males have a poorer nutrition knowledge compared to females has been documented previously (Wardle et al, 2000; Baker & Wardle, 2003), however the present study can offer a more detailed insight in to the domains that provide the most significant differences.

From this study, it appears that there is no statistically significant difference in knowledge of food groups or health and disease. The only statistically significant result from the nutrition knowledge questionnaire indicated that females performed better on the expert advice and recommendations element. This signifies that females are more aware of the advice provided by experts in the field of nutrition and may have been more aware of the recommendations for fruit and vegetable intake. This suggests that more work should be carried out to raise the awareness of the recommended fruit and vegetable intake for males in order to empower them to increase their fruit and vegetable intake. There are very few recent studies that have attempted to evaluate the reasons for the gap in nutrition knowledge between males and females so more research is required to assess possible influencing factors so that the gap can be reduced.

The present study assessed fruit and vegetable related declarative nutrition knowledge of a very small sample in a LLSOA. More research should focus on assessing the nutrition knowledge of males and females in a wider population demographic of the UK. Should the results follow a similar trend to those analysed previously, new methods and interventions should be sought to specifically target males.

It must be noted that the fact that there was no significant difference in vegetable consumption or combined fruit and vegetable consumption between males and females suggests that expert advice and knowing the recommendations may not be an influential factor in instigating behaviour change between genders. Additional factors that were not accounted for in this study but may have an influential contribution to fruit and vegetable consumption between males and females include physical activity levels, smoking and alcohol status, intrinsic motivation, beliefs, barriers and stage of dietary change (Trudeau, Kristal, Li, & Patterson, 1998). No study has successfully identified the most significant contributing factor.

4.3. Differences between age groups

This study suggests that there is no significant link between age and fruit and vegetable intake. In contrast, Murphy et al. (2012) identified that as age increased, so did fruit and vegetable consumption. This difference may be explained by the collection of the age data as the present study grouped the age categories and included a minimum (17 years) and maximum (44 years) age limit whereas the study conducted by Murphy et al (2012) included exact ages and no minimum or maximum ages were stated. Therefore it was much easier to identify a correlation as the ages were more varied.

In contrast, Wolf et al. (2008) concluded that age was not correlated with fruit and vegetable consumption thus supporting the results of the present study although the data from Wolf et al. (2008) was collected from an urban population of black men in New York City in the US rather than a LLSOA in the North West of England where the population ethnic demographic is approximately 95% white British (Cheshire West and Chester Council, 2011).

Furthermore the participants in the 17-24 year age group in this study appeared to consume more fruit and vegetables than participants in similar age categories from previous studies. Larson, Laska, Story and Neumark-Sztainer (2012) identified that young adults (mean ages

20.4 +/- 0.8 years and 26.2 +/- 0.8 years) consumed an average of 2.7 servings of fruit and vegetables per day whereas the 17-24 year age group in this study consumed 3.4 +/- 0.8 portions of fruit and vegetables. Larson et al. (2012) didn't assess nutrition knowledge and the present study didn't assess lifestyle factors so it is very difficult to compare the reasonings for the difference in these fruit and vegetable consumptions.

Similarly 22% of the participants in the 17-24 year age group in this study reported to consume five portions or more fruit and vegetables per day whereas Boone-Heinonen et al. (2011) identified that only 7% of the participants (mean age 24.8 +/- 0.1 years) in their study met the recommendations. This may be due to the vast difference in participant numbers but, again, the difference in the target of the studies makes it very difficult to explain the reasons behind the differences in fruit and vegetable consumption. Boone-Heinonen et al. (2011) were spcifically assessing the influence of fast food restaurants and food stores on diet rather than nutrition knowledge as described in the present study.

Furthermore, there appeared to be no significant difference in overall declarative nutrition knowledge between age groups although the older age group (35-44 years) performed significantly better than the middle age group (25-34 years) when answering questions on the relevance of eating fruits and vegetables to improve health and prevent disease.

Interestingly there was no significant difference between the older age group and the youngest age group for the same topic (17-24) although table 3 portrays that there may have been a non-significant trend showing that the older age group performed better. One possible reason for there being no significant difference between the older age group and the youngest age group is that some of the younger age group may have recently left education so they would have more recently been made aware of healthy eating and nutrition. Alternatively the small sample size may have accounted for the lack of significance.

Parmenter et al. (2000) identified similar results with nutrition knowledge improving with age up to approximately 65 years ($F[4,1038] = 16.2$, $P < 0.001$ for total score). This study used the full version of the nutrition knowledge questionnaire as the present study but Parmenter et al. (2000) recruited participants from a wider demographic, which may have effected the results as they also observed that nutrition knowledge was better for those in a higher socail class ($F[5,810] = 16.2$, $P < 0.001$).

The hypothesis that nutrition knowledge can be enhanced purely by ageing by one year is non-sensical so more evidence is required to assess the reasons why this is apparent. One reason may be that health becomes more of a priority as age and risk of diseases increases and therefore the younger age group spend less attention to health messages. The relevance of nutrition knowledge for the youngest age groups may vary depending on food preferences, food availability and their socioeconomic status, which may all contribute to fruit and vegetable consumption (Larson et al, 2012).

A further reason may be that health messages are reaching those of an older age and not those of younger age. This seems unlikely as most people would expect the younger age group to generally have access to more technology and spend more time browsing the internet. Alternatively it may be that the nutrition taught in an educational setting may not be substantial or that more emphasis is placed on procedural knowledge e.g. how to cook certain foods rather than declarative.

Whatever the reason, more studies should view age as an important influential factor when assessing nutritional knowledge variation amongst the UK population.

4.4. Fruit and vegetable intake and nutrition knowledge

The results of this study indicate that there is evidence for a significant, positive, weak-to-moderate strength relationship between overall declarative nutrition knowledge and combined fruit and vegetable intake of residents of Blacon aged 17-45 years. Furthermore the present study suggests that 10.89% of the variation in fruit and vegetbale consumption can be predicted by declarative nutrition knowledge. These results are very similar to those described by Wardle et al. (2000) when assessing nutrition knowledge and food consumption of 1040 participants from Essex, Lancashire and Oxfordshire. In this study, Wardle et al. (2000) were able estimate that nutrition knowledge was explaining between 4% and 22% of the variation in food intake.

No significant correlation was apparent between fruit intake and overall declarative nutrition knowledge or any other nutrition knowledge elements (expert advice, food groups and health and disease). Contrastingly, when analysed seperately from fruit consumption, vegetable intake was significantly associated with overall nutritional knowledge and knowledge of expert advice and health and disease.

Baker and Wardle (2003) combined fruit and vegetable intake when conducting a regressional analysis against gender, dieting status, nutrition knoweldge, food preferences and attitiude. While this identified a positive relationship between nutrition knowledge and fruit and vegetable intake, it wasn’t possible to identify whether the link was more significantly associated with fruit rather than vegetables or vice versa. Similarly it was impossible to tell whether any of the seperate individual elements of the nutritional knowledge questionnaire were more significant contributors to fruit and vegetable intake.

The present study suggests that nutrition knowledge is significantly positive correlated with vegetable intake. Furthermore, the present study proposes that understanding the effects of fruit and vegetables on human health and being aware of the advice that experts communicate provides a positive correlation with vegetable intake (although relatively weak). This correlation may be partly explained by the Health Belief Model (Hochbaum, 1958), i.e. if a person believes that a certain behaviour will be detrimental to their health, they are more likely to change it. By understanding that not eating fruit and vegetables could increase susceptibility of severe NCD's such as CHD, cancer and Alzheimers, individuals would be more likely to increase their consumption.

4.5. Practical implications

Although a positive relationship exists between declarative nutrition knowledge and fruit and vegetable consumption for residents of Blacon, the results from this correlational analysis suggest that can not confirm that there is a cause-effect relationship. What is illustrated however, is that 10.89% of the variance in fruit and vegetable intake can be predicted by declarative nutrition knowledge. It is clear from this low value that other factors may have a stronger influence but past research has observed a cause-effect relationship between the two (Wardle et al, 2000; Baker & Wardle, 2003). This suggests that experts should continue to convey health messages and recommendations to residents of areas of deprivation, specifically Blacon, in an attempt to increase vegetable intake. As the fruit and vegetable intake is still relatively low, this suggests that current interventions have been unsuccessful in attempting to increase the amount of fruit and vegetables consumed.

This is supported by previous studies including Wolf et al. (2008) who identified that a greater level of fruit and vegetable consumption was associated with greater knowledge of fruit and vegetable recommendations ($F (2,460) = 6.48$, $p<0.01$) for an urban population of black men in New York City. There was also significant associations between fruit and vegetable consumption and stage of change and perceived barriers whereas perceived health benefits and demographic variations were not significantly associated with fruit and vegetable consumption.

Furthermore, Erinosho, Moser, Oh, Nebeling & Yaroch (2012) found that while only 29% of Americans were meeting the recommended 5 portions of fruit and vegetables per day, fruit and vegetable consumption was associated with the awareness of campaigns such as “5 A Day” and “Fruits and Veggies- More Matters”. Whether the results of these two USA-based studies could be applied to the UK population is questionable due to the difference in demographic of the populations.

In contrast to Wolf et al. (2008) and Erinosho et al. (2012), Beaudoin, Fernandez, Wall and Farley (2008) conducted a short term (five month) health campaign in conjunction with the Louisiana Public Health Institiute, the City of New Orleans, the Centers for Disease Control and Prevention and the Energy Charitable Foundation. They found that while the campaign encouraged more positive attitudes towards healthy eating and physical activity, it didn’t instigate behaviour change. This campaign included television and radio advertisements, taillight bus signs, large side-panel bus signs, taillight street car signs and large side-panel street car signs so the exposure was significant. The failure of the campaign to instigate behaviour change may have been due to the short duration of the exposure (6 months). Furthermore, this campaign only targetted a small cross-section of the population (African-American women aged 18-49 years in New Orleans) and if it had been rolled out across the entire country, more significant changes in behaviour may have been apparent.

While the UK also has the long-term, fruit and vegetable specific, established ‘5 A Day’ campaign (Department for Environment, Food and Rural Affairs, 2004), additional food/nutrition campaigns include ‘Change4Life’ (NHS, 2014), ‘Be Food Smart’ (Soubry, 2013) and ‘Salt Reduction’ (Food Standards Agency, 2013) but none of these additional campaigns focus specifically on fruit and vegetables. The results from this study highlight that campaigns such as these could have a positive effect on food consumption, particularly in Blacon, but the low fruit and vegetable consumption in the area suggest that the campaigns aren’t achieveing their targets.

A few studies have attempted to quantify the success of the “5 A Day” campaign since it was introduced in 2002 by assessing the percentage of the UK population that are aware of the campaign, whether the message within the campaign has been understood and whether awareness of the campaign is associated with a higher fruit and vegetable consumption (Cullum, 2003; Bremner, Dalziel & Evans, 2006; Capacci & Mazzocchi, 2011).

While all studies suggest that awareness of the positive health effects of fruit and vegetable consumption has increased due to the campaign, only Capacci and Mazzocchi (2011) identified a significantly higher fruit and vegetable consumption compared to the 2002 baseline due to the campaign (+ 0.3 portions). A reason for this may have been that this study was most recent and was able to fully analyse the first 3 years of the campaign against the baseline (2002-2005) whereas the previous three studies were conducted over a shorter time period. This is supported by the fact that Capacci and Mazzocchi (2011) didn’t find a significant increase in the age standardized, average overall consumption in the initial two years of the campaign.

The reasoning behind the apparent failure of the campaign to deliver practical results on a yearly basis i.e. encourage the population to consume significantly higher quantities of fruit and vegetables is unclear. It may be that the campaign is not reaching the population areas that fruit and vegetable consumption is lowest or it may be that the campaign has reached all areas of the UK but the message has either been misunderstood or perceived as being an unachievable target. In contrast, the results may be predominantly time-related and the longer the campaign continues, the greater the impact may be on fruit and vegetable consumption as suggested by Capacci and Mazzocchi (2011). Furthermore, it may be due to the previously discussed ‘deprivation amplification’ so the message may be reaching areas where fruit and vegetable consumption is low but the environmental factors place barriers that residents of these areas find difficult to overcome.

Due to the conflicting evidence and the complex nature of altering food consumption in areas of deprivaton, very few practical models exist to illustrate ways and processes of improving this issue. One such model that has, however, identified nutrition knowledge as an important factor that influences diet and physical activity is the Ecological Model of Factors Influencing Diet and Physical Activity (Fitzgerald & Spaccarotella, 2009). This model identifies 5 components that influence diet and physical activity. These include individual, interpersonal, community, institutions and policies. Nutrition knowledge fits in to the individual component and is therefore the foundation for all the other components when making a food choice. If nutrition knowledge is not appropriate then all the other components become unstable and a poor choice is made thus highlighting the importance of nutrition knowledge when analysing food choice. As evidence accumulates, more models can be formulated, which will be used when designing interventions for the UK population in an attempt to improve diet thus emphasising the importance of assessing whether there is a significant link between nutrition knowledge and food intake.

Furthermore, as nutrition knowledge, and particularly declarative nutrition knowledge, is classed as intrapersonal and within the control of the individual (Fitzgerald & Spaccarotella, 2009), this can be transformed and used as appropriate by the individual without the requirement of health experts, once the information has been delivered.

Before these models can be designed, additional stimuli that food behaviours can be moulded from should be researched. These include perceived consequence of behaviour, social and environmental factors, attitudes and ethical beliefs, skills, confidence and motivators (biological needs, environmental rewards, psychogenic needs and cultural values) (Worsley, 2002; Barton, Kearney and Stewart-Knox, 2011). These should be compared against the positive correlation portrayed by nutrition knowledge and fruit and vegetable consumption in areas of deprivation such as Blacon.

Additionally, should nutrition knowledge be an influential factor solely for daily vegetable intake, as the present study suggests, more research is required to understand the most influential factors for daily fruit intake in order to increase the amount of fruit consumed by those living in areas of deprivation and specifically, Blacon.

5.0. Limitations

This study didn't account for demographic and psychosocial variables such as smoking status, alcohol intake, physical activity status, ethnicity, intrinsic motivation, perceived consequence of behaviour, skills, confidence or stage of change, all of which have been shown to contribute to fruit and vegetable consumption (Trudeau, 1998; Worsley, 2002). The aim of this study however, was to solely assess the influence of nutrition knowledge on fruit and vegetable consumption rather than any other factor. Furthermore, this study failed to compare populations from a LLSOA to that of a more affluent area to assess whether nutrition knowledge was more or less significant in predicting fruit and vegetable consumption depending on socioeconomic status.The conclusions from this study may have been more relevant on a broader scale had this have occurred, especially when deciding who to target and how to communicate health messages on a wider geographical scale.

Additionally, the title of this study was decided and ethical approval obtained in 2011 (appendix A) and the data collection occurred in 2012, 2 years prior to the discussion due to nutrition-related work commitments for the lead researcher. More recent advice and recommendations are available for the population so this may have had an influence on the results compared to those obtained in 2012.

Moreover, the present study was only used to collect quantitative data in order to assess the correlation and compare scores of participants. By introducing a qualitative element, such as a focus group, this would have allowed the participants to give their views on whether they believed they were receiving appropriate advice, recommendations and support from health professionals regarding fruit and vegetable consumption.

Furthermore, due to the small sample size, it was very difficult to accurately assess the linear or curvilinear relationship of the data when choosing which statistical test to use to analyse correlation. Although some relationships appeared curvilinear when the ranges of the x and y axis were short, a wider axis range suggests the relationship may have been linear if a higher volume of participants had completed the questionnaires.

In addition, the study was not able to confirm a cause-effect relationship between fruit and vegetable consumption and nutrition knowledge. This could be analysed in future by using regression methods.

Finally, the non-proportional quota sampling strategy described in the methods section was not achieved. This resulted in the three age groups having unequal numbers, which may have effected the analysis as the smallest group (17-24 years) would have required a higher proportion of participants to achieve similar results in order for them to be classified as statistically significant. This was also the case for gender as many more females participated than males. The lack of non-proportional quota sampling may have been due to the small sample size (45 compared to the 102 generated by the previously validated GPower 3.1.2) (Faul et al, 2007) and the varying age ranges of the attendees at the events and locations used for data collection. A larger sample size may have produced slightly different results and offered more valid outcomes and conclusions.

6.0. Conclusion

The significant findings from this study indicate that, while food intake is a very complex issue involving a wide range of factors, declarative nutrition knowledge could be used to predict a small percentage of variance of fruit and vegetable intake in Blacon. This is significant for health authorities, governments and local communities, as efforts should continue to convey health messages and provide advice to the people in areas of health deprivation in an attempt to increase the amount of fruit and vegetables consumed and reduce the risk of certain NCD's.

References

Alzheimers Society. (2011). *Statistics*. Retrieved from the Alzheimers Society website: http://www.alzheimers.org.uk/site/scripts/documents_info.php?documentID=341

Anderson, J. R. (1995). *Cognitive psychology and its implications* (4th ed.). W.H. Freeman and Company: New York.

Baker, A. H., & Wardle, J. (2003). Sex differences in fruit and vegetable intake in older adults. *Appetite*, *40*(3), 269-275.

Barrett, D. M., Beaulieu, J. C., & Shewfelt, R. (2010). Color, flavor, texture and nutritional quality of fresh-cut fruits and vegetables: Desirable levels, instrumental and sensory measurement, and the effects of processing. *Critical Reviews in Food Science and Nutrition*, *50*(5), 369-389.

Barta, I., Smerak, P., Polivkova, Z., Sestáková, H., Langová, M., Turek, B., & Bártová, J. (2006). Current trends and perspectives in nutrition and cancer prevention. *Neoplasma*, *53*, 19–25.

Barton, M., Kearney, J., & Stewart-Know, B. J. (2011). Knowledge of food production methods informs attitudes toward food but not food choice in adults residing in socioeconomically deprived rural areas within the United Kingdom. *Journal of Nutrition Education and Behaviour, 43*(5), 374-378.

Basu, A. Rhone, M., & Lyons, T. (2010). Berries: Emerging impact on cardiovascular health. *Nutrition Reviews, 68*, 168-177.

Bates, B., Lennox, A. & Swan, G. (2010). *National Diet and Nutrition Survey; Headline results from year 1 of the rolling programme (2008/09)*. Retrieved from UK Government website: http://tna.europarchive.org/20110116113217/tna.europarchive.org/20110116113217/http://www.food.gov.uk/ science/dietarysurveys/ndnsdocuments/ndns0809year1

Bates, B., Lennox, A. & Swan, G. (2011). *National Diet and Nutrition Survey; Headline results from years 1 and 2 (combined) of the rolling programme (2008/09-2009/10)*. Retrieved from UK Government website: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166

Bates, B., Lennox, A., & Swan, G. (2012). *National Diet and Nutrition Survey; Headline results from years 1 and 2 (combined) of the rolling programme (2008/09-2009/10)*. Retrieved from UK Government website: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166

Beaglehole, R., Bonita, R., Horton, R., Adams, C., Alleyne, G., Asaria, P., … Keeling, A. (2011). Priority actions for the non-communicable disease crisis. *The Lancet, 377*(9775), 1438-1447.

Beaudoin, C. E., Fernandez, C., Wall, J. L., & Farley, T. A. (2008). Promoting Healthy Eating and Physical Activity. *American Journal of Preventive Medicine, 32*(3), 217-223.

Boeing, H., Bechthold, H., Bub, A., Ellinger, S., Haller, D., Kroke, A., … Watzl, B. (2012). Critical review: vegetables and fruits in the prevention of chronic diseases. *European Journal of Nutrition, 51*, 637-663.

Boone-Heinonen, J., Gordon-Larsen, P., Kiefe, C. I., Shikany, J. M., Lewis, C. E., & Popkin, B. M. (2011). Fast food restaurants and food stores longitudinal association with diet in young to middle-aged adults: The CARDIA study. *Archives of Internal Medicine, 171*(13), 1162-1170.

Boyle, P., & Langman, J. S. (2000). ABC of colorectal cancer. *British Medical Journal, 30*(321), 805-808.

Bremner, P., Dalziel, D., & Evans, L. (2006). *Evaluation of the 5 a day programme. Final report*. London, United Kingdom: Big Lottery Fund.

British Dietetic Association. (2011). *Fruit and vegetables- how to get 5 a day*. Retrieved from BDA website: https://www.bda.uk.com/foodfacts/home

British Heart Foundation. (2008). *Phytochemicals, antioxidants and the heart*. Retrieved from British Heart Foundation website: http://www.bhf.org.uk/plugins/PublicationsSearchResults/DownloadFile.aspx?docid=a89d55d9-b1ee-4d0d-9cb8-ee60ebe2aaa2&version=-1&title=Antioxidants&resource=IS69

British Heart Foundation. (2010). *Cardiovascular Disease Statistics*. Retrieved from British Heart Foundation website: http://www.bhf.org.uk/heart-health/heart-statistics.aspx

British Heart Foundation Statistics Database. (2011). *Age-specific CHD death rates by sex, United Kingdom 1968-2010*. Retrieved from British Heart Foundation website: http://www.bhf.org.uk/research/heart-statistics/mortality/time-trends.aspx

British Nutrition Foundation. (2011). *Dietary fibre*. Retrieved from http://www.nutrition.org.uk/healthyliving/basics/fibre

Cancer Research UK. (2009). *Diet and cancer: The evidence*. Retrieved from Cancer Research UK website: http://www.cancerresearchuk.org/cancer-info/healthyliving/dietandhealthyeating/howdoweknow/diet-and-cancer-the-evidence

Capacci, S., & Mazzocchi, M. (2011). Five-a-day, a price to pay: An evaluation of the UK program impact accounting for market forces. *Journal of Health Economics, 30*(1), 87-98.

Carter, P., Gray, L. J., Troughton, J., Khunti, K., & Davies, M. J. (2010). Fruit and vegetable intake and incidence of type 2 diabetes mellitus: systematic review and meta-analysis. *British Medical Journal, 341*, C4229.

Cheshire West and Chester Council. (2011). Joint Strategic Needs Assessment. Retrieved from http://www.cheshirewestandchester.gov.uk/your_council/key_statistics_and_data/jsna-1.aspx

Cohen, J. H., Kristal, A. R., & Stanford, J. L. (2000). Fruit and vegetable intake and prostate cancer risk. *Journal of the National Cancer Institute, 92*(1), 61-68.

Cullum, A. (2003). Increasing the fruit and vegetable consumption: the 5 a day programme. *Nutrition Bulletin, 28*(2), 159-163.

Cummins, S., & Macintyre, S. (2006). Food environments and obesity- neighbourhood or nation? *International Journal of Epidemiology, 35*(1), 100-104.

Dai, Q., Borenstein, A. R., Wu, Y., Jackson, A. C., & Larson, E. B. (2006). Fruit and vegetable juices and alzheimers disease: The Kame project. *The American Journal of Medicine, 119*(9), 751-759.

Darmon, N., & Derwnowski, A. (2008). Does social class predict diet quality. *The American Journal of Clinical Nutrition, 87*(5), 1107-1117.

Dauchet, L., Amouyel, P., Hercberg, S., & Dallongeville, J. (2006). Fruit and vegetable consumption and risk of coronary heart disease: A meta-analysis of cohort studies. *The Journal of Nutrition, 136*(10), 2588-2593.

Department for Environment, Food & Rural Affairs. (2004). *5 A DAY Programme*. London, United Kingdom: DEFRA.

Dickson-Spillmann, S., & Siegrist, M. (2011). Consumers knowledge of healthy diets and its correlation with dietary behaviour. *Journal of Human Nutrition and Dietetics, 24*(1), 54-60.

Dickson-Spillmann, M. Siegrist, M., & Keller, C. (2011). Development and validation of a short, consumer-orientated nutrition knowledge questionnaire. *Appetite, 56*(3), 617-620.

Doll, R., & Peto, R. (1981). The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. *Journal of the National Cancer Institute, 66,* 1191–308.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Journal of Psychology, 49*(8), 709-724.

Epstein, L. H., Gordy, C. C., Raynor, H. A., Beddome, M., Kilanowski, C. K., & Paluch, R. (2001). Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity. *Obesity Research, 9*(3), 171-178.

Erinosho, T. O., Moser, R. P., Oh, A. Y., Nebeling, L. C., & Yaroch, A. L. (2012). Awareness of the Fruits and Veggies- More Matters campaign, knowledge of the fruit and vegetable recommendation, and fruit and vegetable intake of adults in the 2007 Food Attitudes and Behaviors (FAB) survey. *Appetite, 59*, 155-160.

Evans, J. M., Newton, R. W., Ruta, D. A., MacDonald, T. M., & Morris, A. D. (2000). Socio-economic status, obesity and prevalence of type 1 and type 2 diabetes mellitus. *Diabetic Medicine, 17*, 478–80.

Fagerland, M. W., & Sandvik, L. (2009). The wilcoxon-mann-whitney test under scrutiny. *Statistics in Medicine, 28*, 1487-1497.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Fitzgerald, N., & Spaccarotella, K. (2009). Barriers to a healthy lifestyle: From individuals to public policy- An ecological perspective. *Journal of Extension, 47*(1), 1FEA3. Retrieved from http://www.joe.org/joe/2009february/a3.php

Food Standards Agency. (2002). *McCance and Widdowson's The composition of foods* (6^{th} ed.). Cambridge, United Kingdom: Royal Society of Chemistry.

Food Standards Agency. (2013). *Salt Reduction Strategy*. Retrieved from FSA website: http://www.food.gov.uk/scotland/scotnut/salt/strategy

Ford, E. S., & Capewell, S. (2011). Proportion of the decline in cardiovascular mortality disease due to prevention versus treatment: Public health versus clinical care. *Annual Review of Public Health, 32*, 5-22.

Ford, E. S., & Mokdad, A. H. (2001). Fruit and vegetable consumption and diabetes mellitus incidence among US adults. *Preventative Medicine, 32*(1), 33-39.

Gandini, S., Merzenich, H., Robertson, C., & Boyle, P. (2000). Meta-analysis of studies on breast cancer risk and diet: the role of fruit and vegetable consumption and the intake of associated micronutrients. *European Journal of Cancer, 36*(5), 636-646.

George, S. M., Park, Y., Leitzmann, M. F., Freedman, N. D., Dowling, E. C., Reedy, J., Schatzkin, A., Hollenbeck, A., & Subar, A.F. (2009). Fruit and vegetable intake and risk of cancer: a prospective cohort study. *American Journal of Clinical Nutrition, 89*, 1-7.

Giskes, K., Turrell, G., Patterson, C., & Newman, B. (2002). Socio-economic differences in fruit and vegetable consumption among Australian adolescents and adults. *Public Health Nutrition. 5*(5), 663-669.

Griep, L. M. O., Geleijnse, J. M., Kromhout, D., Ocké, M. C., & Verschuren, W. M. M. (2010). Raw and processed fruit and vegetable consumption and 10-year coronary heart disease incidence in a population-based cohort study in the Netherlands. *PLoS ONE, 5*(10). doi:10.1371/journal.pone.0013609.

Griep, L. M. O., Geleijnse, J. M., Kromhout, D., Ocké, M. C., & Verschuren, W. M. M. (2012). Variety in fruit and vegetable consumption and 10-year incidence of CHD and stroke. *Public Health Nutrition, 15*(12), 2280-2286.

Grimm, K. A., Foltz, J. L., Blanck, H. M., & Scanlon, K. S. (2012). Household income disparities in fruit and vegetable consumption by state and territory: Results of the 2009 behavioural risk factor surveillance system. *Journal of the Academy of Nutrition and Dietetics*, *112*(12), 2014-2021.

Ha, E., & Caine-Bish, N. (2009). Effect of nutrition intervention using a general nutrition course for promoting fruit and vegetable consumption among college students. *Journal of Nutrition Education and Behavior, 41*(2), 103-109.

Hall, J. N., Moore, S., Harper, S. B., & Lynch, J. W. (2009). Global variability in fruit and vegetable consumption. *American Journal of Preventive Medicine*, *36*(5), 402-409.

Hamer, M., & Chida, Y. (2007). Intake of fruit, vegetables, and antioxidants and risk of type 2 diabetes: systematic review and meta-analysis. *Journal of Hypertension, 25,* 2361-2369.

Harding, A., Wareham, N. J., Bingham, S. A., Khaw, K., Luben, R., Welch, A., & Forouhi, N. G. (2008). Plasma vitamin c level, fruit and vegetable consumption, and the risk of new-onset type 2 diabetes mellitus. *Archives of Internal Medicine*, *168*(14), 1493-1499.

Havas, S., Treiman, K., Langenberg, P., Ballesteros, M., Anliker, J., Damron, D., & Feldman, R. (1998). Factors associated with fruit and vegetable consumption among women participating in WIC. *Journal of the American Dietetic Association, 98*(10), 1141-1148.

Hiza, H. A. B., Casavale, K. O., Guenther, P. M., & Davis, C. A. (2013). Diet quality of Americans differ by age, sex, race/ethnicity, income and education level. *Journal of the Academy of Nutrition and Dietetics*, *113*(2), 297-306.

Hochbaum, G. (1958). Public Participation in Medical Screening Programs: A Sociopsychological Study. Washington DC: US Government Printing Office.

Honda, K., Casadesus, G., Petersen, R. B., Perry, G., & Smith, M. A. (2004). Oxidative stress and redox-active iron in Alzheimer's disease. *Annals of the New York Academy of Science, 1012*, 179–182.

IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.

Jennings, A., Cassidy, A., Winters, T., Barnes, S., Lipp, A., Holland, R., & Welch, A. (2012). Positive effect of a targeted intervention to improve access and availability of fruit and vegetables in an area of deprivation. *Health and Place, 18*(5), 1074-1078.

Jemal, A., Bray, F., Center, M. M., Ferlay, J., Ward, E., & Forman, D. (2011). Global cancer statistics. *CA: A Cancer Journal for Clinicians*, *61*(2), 69-90.

Kamphuis, C. B., Giskes, K., de Bruijn, G., Wendel-Vos, W., Brug, J., & van Lenthe, F. J. (2006). Environmental determinants of fruit and vegetable consumption among adults: a systematic review. *British Journal of Nutrition*, *96*(4), 620-635.

Kang, J. H., Ascherio, A., & Grodstein, F. (2005). Fruit and vegetable consumption and cognitive decline in aging women. *Annals of Neurology, 57*(5), 517-520.

Key, T. J., (2011). Fruit and vegetables and cancer risk. *British Journal of Cancer, 104*, 6-11.

Key, J. T., Fraser, G. E., Thorogood, M., Appleby, P. N., Beral, V., Reeves, G., … McPherson, K. (1999). Mortality in vegetarians and nonvegetarians: detailed findings from a collaborative analysis of 5 prospective studies. *American Journal of Clinical Nutrition*, *70*(3), 516s-524s.

Key, T. J. A., Thorogood, M., Appleby, P. N., & Burr, M. L. (1996). Dietary habits and mortality in 11,000 vegetarians and health conscious people: results of a 17 year follow up. *British Medical Journal, 313*, 775-779.

Khaw, K. T., Wareham, N., Bingham, S., Welch, A., Luben, R., & Day, N. (2008). Combined impact of health behaviours and mortality in men and women: The EPIC-Norfolk prospective population study. *Public Library of Science and Medicine, 5* (1), e12.

Knekt, P., Reunanen, A., Jarvinen, R., Seppanen, R., Heliovaara, M., & Aromaa, A. (1994). Antioxidant vitamin intake and coronary mortality in a longitudinal population study. *American Journal of Epidemiology, 139*, 1180-1189.

Kratt, P., Reynolds, K., & Shewchuk, R. (2000) The role of availability as a moderator of family fruit and vegetable consumption. *Health Education and Behavior, 27*, 471–482.

Kruskal, W. H. (1952). A nonparametric test for a several sample problem. *The Annals of Mathematical Statistics, 23* (4), 525-540.

Larson, M.G. (2008). Statistical primer for cardiovascular research. *Circulation, 117*, 115-121.

Larson, N., Laska, M. N., Story, M., & Neumark-Sztainer, D. (2012). Predictors of fruit and vegetable intake in young adults. *Journal of the Academy of Nutrition and Dietetics, 112*(8), 1216-1222.

Lucas, K., Tyler, S., & Christodoulou, G. (2008). *The Benefits of Providing New Public Transport in Deprived Areas*. York: The Joseph Rowntree Foundation.

Mackay, J., Mensah, G. A., Mendis, S., & Greenlund, K. (2004). *The atlas of heart disease and stroke*. Brighton, United Kingdom: Myriad Editions.

Macintyre, S. (2007). Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity. *International Journal of Behavioural Nutrition and Physical Activity, 4*(32), http://dx.doi: 10.1186/1479-5868-4-32.

Macintyre, S., Macdonald, L., & Ellaway, A. (2008). Do poorer people have poorer access to local food sources and facilities? The distribution of local resources by area deprivation in Glasgow, Scotland. *Social Science and Medicine, 67*(6), 900-914.

Manach, C., Scalbert, A., Morand, C., Remesy, C., & Jimenez, L. (2004). Polyphenols: food sources and bioavailability. *American Journal of Clinical Nutrition. 79*(5), 727–747.

Miller, H. E., Rigelhof, F., Marquart, L., Prakash, A., & Kanter, M. (2000). Antioxidant content of whole grain breakfast cereals, fruits and vegetables. *Journal of the American College of Nutrition, 19*, S312-319.

Molarius, A., Seidell, J. C., Sans, S., Tuomilehto, J., & Kuulasmaa, K. (2000). Educational level, relative body weight, and changes in their association over 10 years: an international perspective from the WHO MONICA Project. *American Journal of Public Health, 90*, 1260–1268.

Morrow, K. M., Vargas, S., Rosen, R. K., Christensen, A. L., Salomon, L., Shulman, L., … Fava, J. L. (2007). The utility of non-proportional quota sampling for recruiting at-risk women for microbicide research. *AIDS and Behavior, 11*(4), 586-595.

Mozaffarian, D., Kamineni, A., Carnethon, M., Djoussé, L., Mukamal, K. J., & Siscovick, D. (2009). Lifestyle risk factors and new-onset diabetes mellitus in older adults. *Archives of Internal Medicine, 169*(8), 798-807.

Murphy, M. M., Barraj, L. M., Herman, D., Bi, X., Cheatham, R., & Randolph, R. K. (2012). Phytonutrient intake by adults in the United States in relation to fruit and vegetable consumption. *Journal of the Academy of Nutrition and Dietetics, 112*(2), 222-229.

Murray, C. J. L., Richards, M. A., Newton, J. N., Fenton, K. A., Anderson, H. R., Atkinson, C., … Davis, A. (2013). UK health performance: findings of the Global Burden of Disease study 2010. *Lancet*, *381,* 9871: 997-1020.

National Health Service. (2011a). *5 A DAY portion sizes*. Retrieved from NHS website: http://www.nhs.uk/Livewell/5ADAY/Pages/Portionsizes.aspx

National Health Service. (2011b). *Eat less saturated fat*. Retrieved from NHS website: http://www.nhs.uk/Livewell/Goodfood/Pages/Eat-less-saturated-fat.aspx

National Health Service. (2011c). *More evidence that fibre cuts bowel cancer risk.* Retrieved from NHS website: http://www.nhs.uk/news/2011/11November/Pages/high-fibre-diet-reduces-colon-cancer-risk.aspx

National Health Service. (2011d). *Red meat and the risk of bowel cancer*. Retrieved from NHS website: http://www.nhs.uk/Livewell/Goodfood/Pages/red-meat.aspx

National Health Service. (2011e). *Starchy foods*. Retrieved from NHS website: http://www.nhs.uk/Livewell/Goodfood/Pages/starchy-foods.aspx

National Health Service. (2011f). *The facts about sugar*. Retrieved from NHS website: http://www.nhs.uk/Livewell/Goodfood/Pages/sugars.aspx

National Health Service. (2011g). *Why 5 a day?* Retrieved from NHS website: http://www.nhs.uk/Livewell/5ADAY/Pages/Why5ADAY.aspx

National Health Service. (2014). *Change 4 Life*. Retrieved from NHS website: http://www.nhs.uk/Change4Life/Pages/what-is-change-for-life.aspx

National Health Service Confederation. (2007). *Key Statistics on the NHS*. London: NHS Confederation.

Nelson, M. E., Bates, B., Church, S., & Boshier, T. (2007). *Low income diet and nutrition survey*. London: The Stationery Office.

NHS Great Yarmouth and Waveney. (2010). Great Yarmouth and Waveney Joint Strategic Needs Assessment 2009/2010. Retrieved from: http://phi.gywpct.nhs.uk/Images/Uploads/Great%20Yarmouth%20and%20Waveney%20JSNA%20v1.1.pdf〉.

Nooyens, A. C. J., Bueno-de-Mesquita, H. B., van Boxtel, M. P. J., van Gelder, B. M., Verhagen, H., & Verschuren, W. M. M. (2011). Fruit and vegetable intake and cognitive decline in middle-aged men and women: The Doetinchem study. *British Journal of Nutrition, 106*(5), 752-761.

Office of National Statistics. (2010). *The English indices of deprivation 2010*. Retrieved from Communities and Local Government website: http://www.communities.gov.uk/documents/communities/pdf/576659.pdf

Office of National Statistics. (2012). *Cancer incidence and mortality in the United Kingdom, 2008-10*. Retrieved from Communities and Local Government website: http://www.ons.gov.uk/ons/rel/cancer-unit/cancer-incidence-and-mortality/2008-2010/stb-cancer-incidence-and-mortality-in-the-united-kindom--2008-2010.html

Ornish, D., Scherwitz, L. W., Billings, J. H., Gould, K. L., Merritt, T. A., Sparler, S., … Brand, R. J. (1998). Intensive lifestyle changes for reversal of coronary heart disease. *Journal of the American Medical Association, 280*, 2001-2007.

Palmer, S. M., Salisbury-Glennon, J., Shannon, D., & Struempler, B., (2009). School gardens:An experiential learning approach for a nutrition education program to increase fruit and vegetable knowledge, preference, and consumption among second-grade students. *Journal of Nutrition Education and Behavior, 41*(3), 212-217.

Parmenter, K., & Wardle, J. (1999). Development of a general nutrition knowledge questionnaire for adults. *European Journal of Clinical Nutrition, 53*, 298–308.

Parmenter, K., Waller, J., & Wardle, J. (2000). Demographic variation of nutrition knowledge in England. *Health Education Research, 15*(2), 163-174.

Parmer, S.M., Salisbury-Glennon, J., Shannon, D., & Struempler, B. (2009). School gardens: An experiential learning approach for a nutrition education program to increase fruit and vegetable knowledge, preference, and consumption among second-grade students. *Journal of Nutrition, Education and Behavior, 41*(3), 212-217.

Pearson, N., Atkin, A. J., Biddle, S. J. H., Gorley, T., & Edwardson, C. (2009). Pattern of adolescent physical activity and dietary behaviours. *International Journal of Behavioural Nutrition and Physical Activity, 6*, 45.

Pearson, D., Taylor, R., & Masud, T. (2004). The relationship between social deprivation, osteoporosis, and falls. *Osteoporosis International, 15*, 132–138.

Perez, C.E. (2002). Fruit and vegetable consumption. *Health Reports*, *13*(3), 23-31.

Pomerleau, J., Lock, K., Knai, C., & McKee, M. (2005). Interventions designed to increase adult fruit and vegetable intake can be effective: a systematic review of the literature. *The Journal of Nutrition*, *135*, 2486–2495.

Reynolds, K. D., Baranowski, T., Bishop, D. P., Farris, R. P., Binkley, D., Nicklas, T. A., & Elmer, P. J. (1999). Patterns in child and adolescent consumption of fruit and vegetables: effects of gender and ethnicity across four sites. *Journal of the American College of Nutrition, 18*, 248-255.

Rodgers, J. L., & Nicewander, W. A. (1988). Thirteen ways to look at the correlation coefficient. *The American Statistician, 42*(1), 59-66.

Roe, D. A. (1986). History of promotion of vegetable cereal diets. *Journal of Nutrition, 16*(1), 1355-1363.

Roe, L., Strong, C., Whiteside, C., Neil, A., & Mant, D. (1994). Dietary intervention in primary care: validity of the DINE method for diet assessment. *Family Practice, 11*, 375–381.

Scientific Advisory Commission on Nutrition. (2003). *Salt and health*. Retrieved from UK Government website: http://www.sacn.gov.uk/reports_position_statements/reports/salt_and_health_report.html

Serdula, M. K., Coates, M. J., Byers, T., Simoes, E., Mokdad, A. H., & Subar, A. F. (1995). Fruit and vegetable intake among adults in 16 states: results of a brief telephone survey. *American Journal of Public Health, 85*(2), 236-239.

Serdula, M. K., Byers, T., Mokdad, A. H., Simoes, E., Mendlein, J. M., & Coates, M. J. (1996). The association between fruit and vegetable intake and chronic disease risk factors. *Epidemiology*, *7*(2), 161-165.

Serdula, M. K., Gillespie, C., Kettel-Khan, L., Farris, R., Seymour, J., & Denny, C. (2004). Trends in fruit and vegetable consumption among adults in the United States: behavioral risk factor surveillance system, 1994-2000. *American Journal of Public Health, 94*(6), 1014-1018.

Shaw, J. E., Sicree, R. A., & Zimmet, P. Z. (2010). Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice, 87*, 4-14.

Shepherd, R., & Stockley, L. (1987). Nutrition knowledge, attitudes and fat consumption. *Journal of the American Dietetic Association, 87*, 615-619.

Shohaimi, S., Welch, A., Binham, S., Luben, R., Day, N., Wareham, N., & Khaw, K. (2004). Residential area deprivation predicts fruit and vegetable consumption independently of individual educational level and occupational social class: a cross sectional population study in the Norfolk cohort of the European Prospective Investigation into Cancer (EPIC-Norfolk). *Journal of Epidemiology and Community Health, 58,* 686-691.

Siega-Riz, A., & Popkin, B. (2001) Dietary trends among low socioeconomic status women of childbearing age in the United States from 1977 to 1996: a comparison among ethnic groups. *Journal of the American Medical Women's Association, 56*, 44–48.

Slavin, J. L., & Lloyd, B. (2012). Health benefits of fruits and vegetables. *Advances in Nutrition*, *3*, 506-516.

Smith, D.M., Cummins, S., Taylor, M., Dawson, J., Marshall, D., Sparks, L., & Anderson, A.S. (2010). Neighbourhood food environment and area deprivation: spatial accessibility to grocery stores selling fresh fruit and vegetables in urban and rural settings. *The International Journal of Epidemiology*, *39*(1), 277-284.

Soubry, A. (2013). *'Be Food Smart' Campaign Launches*. Retrieved from UK Government website: https://www.gov.uk/government/news/be-food-smart-campaign-launches

Subar, A. F., Heimendinger, J., Patterson, B. H., Krebs-Smith, S. M., Pivonka, E., & Kessler, R. (1995). Fruit and vegetable intake in the United States: the baseline survey of the Five A Day for Better Health program. *American Journal of Health Promotion*, *9*(5), 352-360.

Slavin, J. L., & Lloyd, B. (2012). Health benefits of fruits and vegetables. *Advances in Nutrition*, *3*, 506-516.

Tang, M., Chen, Y., & Krewski, D. (2003). Gender-related differences in the association between socioeconomic status and self-reported diabetes. *International Journal of Epidemiology*, *32*, 381–385.

Townsend, P., Phillimore, P., & Beattie, A. (1988). *Health and Deprivation: Inequality and the North*. London: Croom Helm.

Trudeau, E., Kristal, A. R., Li, S., & Patterson, R. E. (1998). Demographic and psychosocial predictors of fruit and vegetable intakes differ: implications for dietary interventions. *Journal of the American Dietetic Association, 98*(12), 1412-1417.

Vainio, H., & Weiderpass, E. (2006). Fruit and vegetables in cancer prevention. *Nutrition and Cancer*, *54*, 111–42.

Van Duyn, M. A., & Pivonka, E. (2000). Overview of the health benefits of fruit and vegetable consumption for the dietetics professional: selected literature. *Journal of the American Dietetic Association. 100*, 1511–21.

Wallenstein, S., Zucker, C. L., & Fleiss, J. L. (1980). Some statistical methods useful in circulation research. *Circulation Research, 47,* 1-9.

Wardle,J., Parmenter, K., & Waller, J. (2000). Nutrition knowledge and food intake. *Appetite, 34,* 269-275.

Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care*, *27*(5), 1047-1053.

WHO/FAO. (2003). *Diet, nutrition and the prevention of chronic diseases (Report of a joint WHO/FAO expert consultation)***.** Retrieved from WHO website: http://www.who.int/dietphysicalactivity/publications/trs916/en/

Wolf, R. L., Lepore, S. J., Vandergrift, J. L., Wetmore-Arkader, L., McGinty, E., Pietrzak, G., & Yaroch, A. L. (2008). Knowledge, barriers, and stage of change as correlates of fruit and vegetable consumption among urban and mostly immigrant black men. *Journal of the American Dietetic Association*, *108*(8), 1315-1322.

World Cancer Research Fund. (2014). *Plant foods and cancer prevention*. Retrieved from World Cancer Research Fund website: http://www.wcrf-uk.org/cancer_prevention/recommendations/plant_foods_and_cancer.php

World Health Organization. (2002). *Promoting fruit and vegetable consumption around the world*. Retrieved from WHO website: http://www.who.int/dietphysicalactivity/fruit/en/index2.html

Worsley, A. (2002). Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? *Asia Pacific Journal of Clinical Nutrition*, *11*, S5798-S585.

Yeh, M., Ickes, S. B., Lowenstein, L. M., Shuval, K., Ammerman, A. S., Farris, R., & Katz, D. L. (2008). Understanding barriers and facilitators of fruit and vegetable consumption among a diverse multi-ethnic population in the USA. *Health Promotion International*, *23*(1), 42-51.

Appendix A. Ethical approval from the University of Chester

Faculty of Applied Sciences

Research Ethics Committee

Tel 01244 511740

Fax 01244 511302

frec@chester.ac.uk

7th September 2011

Dear Mark,

Study title: Relationship between fruit and vegetable intake and nutrition knowledge of residents in Blacon 17-45 years.

FREC reference: 576/11/MG/CS

Version number: 1

Thank you for providing the documentation for the amendments recommended following the approval of the above application. These amendments have been approved by the Faculty Research Ethics Committee.

With the Committee's best wishes for the success of this project.

Yours sincerely,

Ethics Committee

Appendix B. Participant inclusion criteria questionnaire

Are you a resident of Blacon, Chester?

Yes	
No	

If YES, please state your postcode

....

Are you:

Male	
Female	

Please state which age range you fall in to:

17-24	
25-34	
35-44	
Over 44	

Do you have any health or nutrition related qualifications?

Yes	
No	

What is your job? *If you are not working now, what was your last job?*

....

Appendix C. Nutrition knowledge questionnaire (adapted from Parmenter and Wardle, 1999)

Adaptation from General Nutrition Knowledge Questionnaire for Adults

The first 2 questions are about what advice you think experts are giving us

1. Do you think health experts recommend that people should be eating more, the same amount, or less of these foods? (*tick one box per food*)

	More	**Same**	**Less**	**Not Sure**
Vegetables				
Sugary Foods				
Meat				
Starchy Foods				
Fatty Foods				
High Fibre Foods				
Fruit				
Salty Foods				

2. How many servings of fruit and vegetables a day do you think experts are advising people to eat? (One serving could be, for example, an apple or a handful of chopped carrots)

....

Experts classify foods in to groups. We are interested to see whether people are aware of what foods are in these groups

1. Do you think these are high or low in fibre/roughage? (*tick one box per food*)

	High	**Low**	**Not Sure**
Cornflakes			
Bananas			
Eggs			
Red Meat			
Broccoli			
Nuts			
Fish			
Baked Potatoes with skins			
Chicken			
Baked Beans			

2. A glass of unsweetened fruit juice counts as a helping of fruit

Agree	
Disagree	
Not sure	

This section is about health problems or diseases

1. Are you aware of any major health problems or diseases that are related to a low intake of fruit and vegetable?

Yes	
No	
Not sure	

If yes, what diseases or health problems do you think are related to a low intake of fruit and vegetables?

....
....
....
....

2. Are you aware of any major health problems or diseases that are related to a low intake of fibre?

Yes	
No	
Not sure	

If yes, what diseases or health problems do you think are related to a low intake of fibre?

....
....
....
....

3. Do you think these help to reduce the chances of getting certain kinds of cancer? (answer *each one*)

	Yes	**No**	**Not Sure**
Eating more fibre			
Eating less sugar			
Eating less fruit			
Eating Less salt			
Eating more fruit and vegetables			
Eating less preservatives/additives			

4. Have you heard of antioxidant vitamins?

Yes	
No	

5. If YES to question 4, do you think these are anti-oxidant vitamins?

	Yes	**No**	**Not Sure**
Vitamin A			
B Complex Vitamins			
Vitamin C			
Vitamin D			
Vitamin E			
Vitamin K			

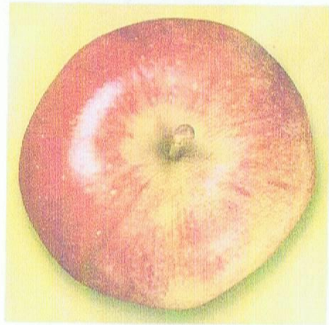
Appendix D: Fruit and vegetable intake questionnaire (adapted from the validated dietary instrument for nutrition education (DINE) (Roe, et al, 1994)

Dietary Instrument for Nutrition Education

About how many times a day do you eat a serving of the following foods? (Choose one on each line)

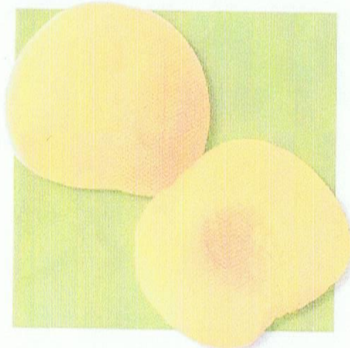
Food	**Less than 1 a day**	**1 a day**	**2 a day**	**3 a day**	**4 a day**	**5 a day**	**6 or more a day**
Vegetables (excluding potatoes)							
Fruit (fresh, frozen or canned)							

Appendix E: Fruit and vegetable portion size guidance (NHS, 2011a)



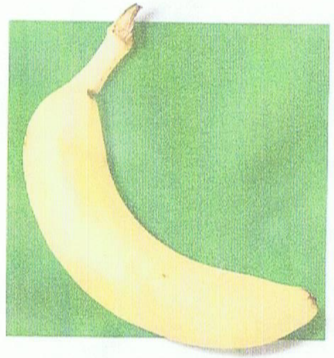
1 medium apple

2 broccoli florets



2 halves of canned peaches

1 handful of grapes



1 medium banana

3 heaped tablespoons of peas

Appendix F: Participant information sheet

Participant information sheet

Fruit and vegetable intake and nutrition knowledge of residents in Blacon

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?

To help understand whether a persons fruit and vegetable consumption depends on the amount of nutrition knowledge they have. This study is also aiming to help understand which adult age group consumes the most vegetables and which age group are the most nutritionally knowledgable.

Why have I been chosen?

You have been chosen because you are a resident of Blacon aged between 17 and 45 years.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

If you decide to take part, you will be given this information sheet to keep and asked to sign the consent form. This will give your consent for you to complete two short questionnaires, We will be giving out approximately 102 questionnaires to adults in Blacon. No-one will be identifiable in the final report.

What are the possible disadvantages and risks of taking part?

There is a very small possibility that the questionnaires may be lost but all the data will be anonymous and represented as group data. All personal information will be kept in a safe at the University of Chester.

What are the possible benefits of taking part?

As a participant in this study you will be offered a summarised version of the results once it has ended. The results of this study will be sent to you via email or telephone if you agree.

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact: Professor Sarah Andrew, Dean of Applied and Health Sciences, University of Chester, Parkgate Road, Chester, CH1 4BJ, Tel: 01244 513055.

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence (but not otherwise), then you may have grounds for legal action, but you may have to pay for this.

Will my taking part in the study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential so that only the researcher carrying out the research will have access to such information.

What will happen to the results of the research study?

The results will be written up into a report. Individuals who participate will not be identified in any subsequent report or publication.

Who is organising and funding the research?

The Centre for Public Health Research at the University of Chester.

Who may I contact for further information?

Mark Gleave

University of Chester,

Parkgate Road,

Chester,

CH1 4BJ,

Email

Thank you for your interest in this research.

Appendix G: Informed consent form

Title of Project: Fruit and vegetable intake and nutrition knowledge of residents in Blacon aged 17-45 years.

Name of Researcher: Mark Gleave Please initial box

1. I confirm that I have read and understood the participant information sheet, dated …………., for the above study and have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without my care or legal right being affected. ☐

3. I agree to take part in the above study. ☐

______________________	____________________	
Name of Participant	Date	
______________________	____________________	____________________
Name of Person taking consent (if different from researcher)	Date	Signature
______________________	____________________	____________________
Researcher	Date	Signature

Appendix H: References for the questions related to expert advice and expert recommendations relevant to fruit and vegetable consumption

Question	Correct Answers	References
Do you think health experts recommend that people should be eating more, the same amount or less of the following foods?	a) More b) Less c) Less d) More e) Less f) More g) More h) Less	(NHS, 2011b; NHS, 2011c; NHS, 2011d; NHS, 2011e ; NHS, 2011f; SACN, 2003)
How many servings of fruit and vegetables a day do you think experts are advising people to eat?	5	(NHS, 2011g)

Appendix I. References for the questions related to food groups relevant to fruit and vegetable consumption

Question	Correct Answer	References
Do you think the following foods are high or low in fibre/roughage?	a) Low b) Low c) Low d) Low e) Low f) High g) Low h) Low i) Low j) High	(FSA, 2002; BNF, 2011;)
A glass of unsweetened fruit juice counts as a helping of fruit	Yes	(NHS, 2011g)

Appendix J. References for the questions related to the impact of fruit and vegetables on health and preventing disease

Question	Correct Answer	References
Are you aware of any major health problems or diseases that are related to a low intake of fruit and vegetables?	High Blood Pressure, Obesity, Heart Disease, Stroke, Cancer, Bone Diseases, Cataracts, Asthma, Bowel Function, CVD, Type II Diabetes, Scurvy	(BDA, 2011; WHO, 2002; NHS, 2011b; NHS, 2011c; NHS, 2011d)
Are you aware of any major health problems or diseases that are related to a low intake of fibre?	Bowel Function, Heart Disease, Stroke, Type II Diabetes, Bowel Cancer, Obesity	(BDA, 2011; WHO, 2002)
Do you think these help to reduce the chances of getting certain kinds of cancer?	a) Yes b) Yes c) No d) Yes e) Yes f) No	(Cancer Research UK, 2009; NHS, 2011c; NHS, 2011d)
Have you heard of antioxidant vitamins?	Yes/No	N/A
Do you think any of these are antioxidant vitamins?	a) Yes b) No c) Yes d) No e) Yes f) No	(BHF, 2008)